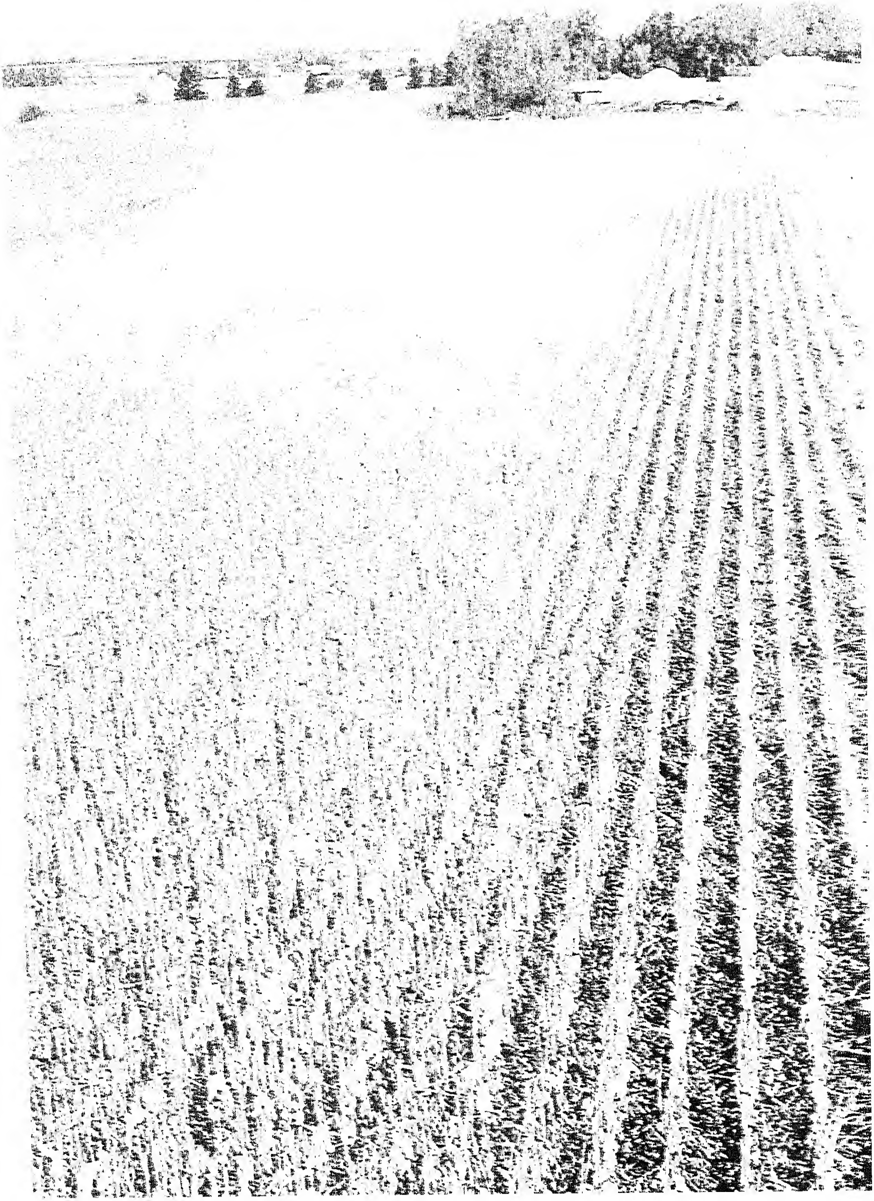
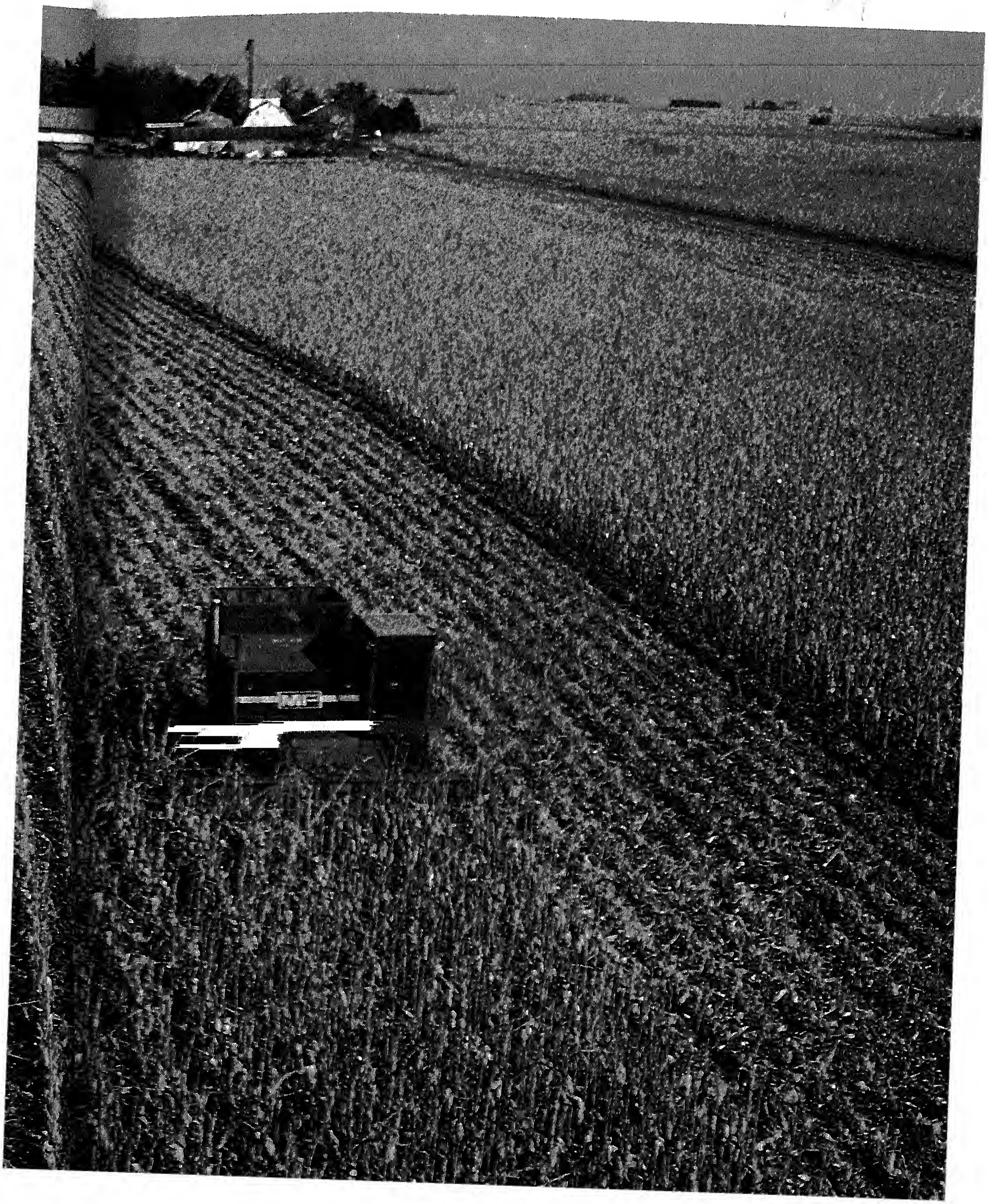
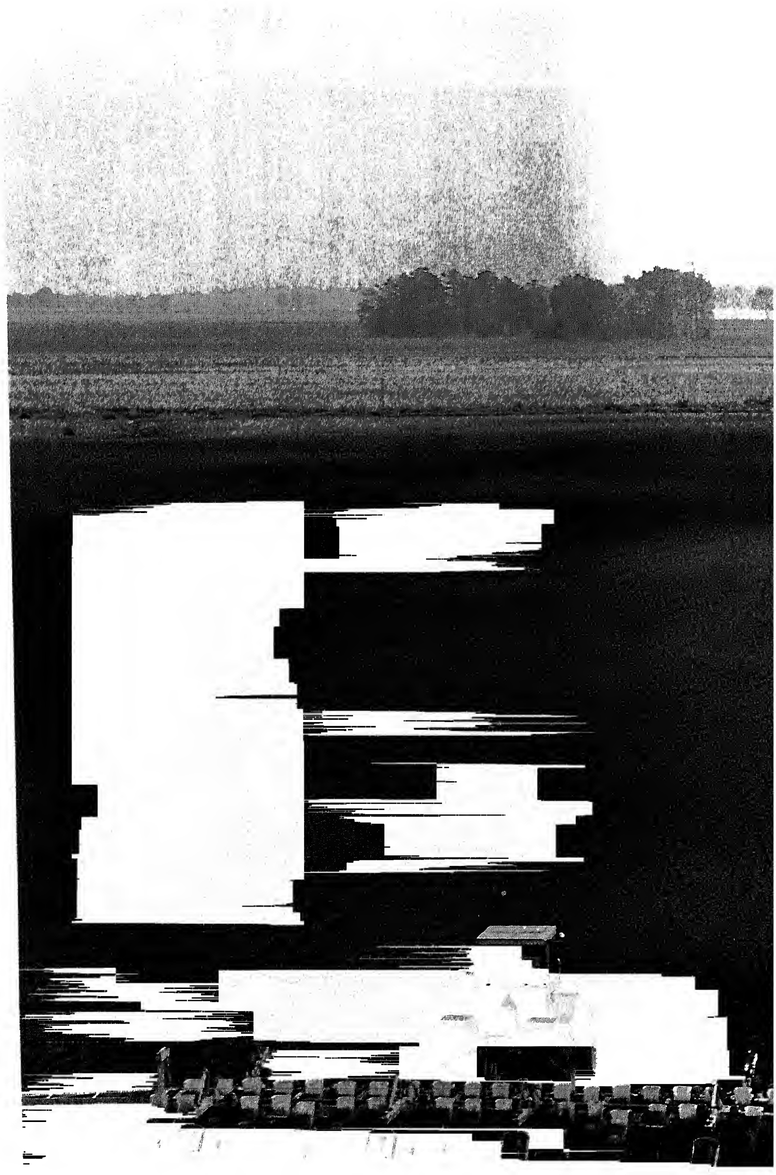
The 1981 Yearbook of Agriculture

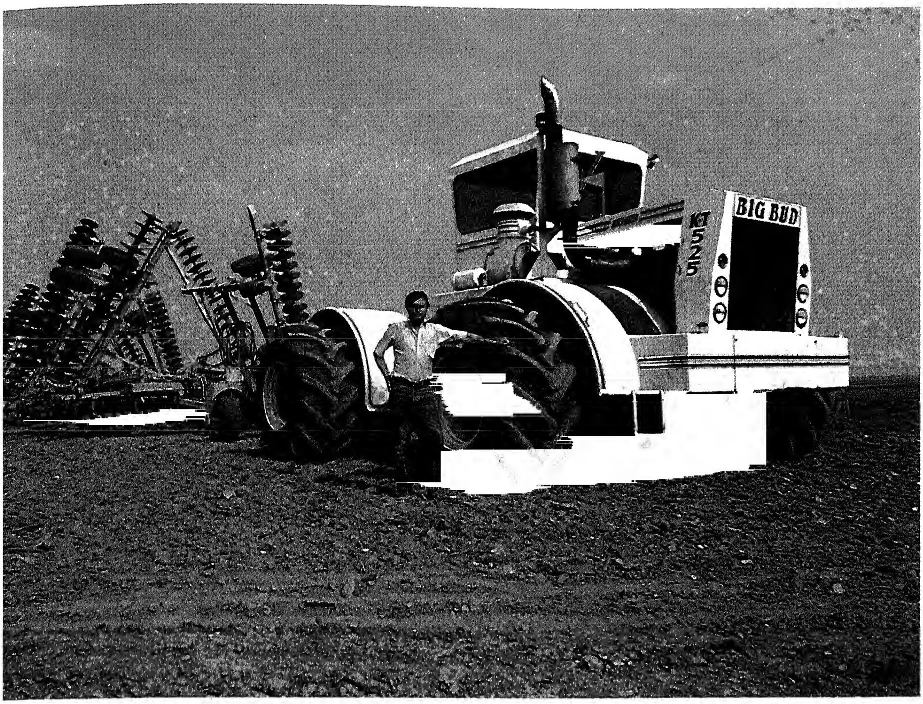


Will there Be Enough Food?

United States Department of Agriculture





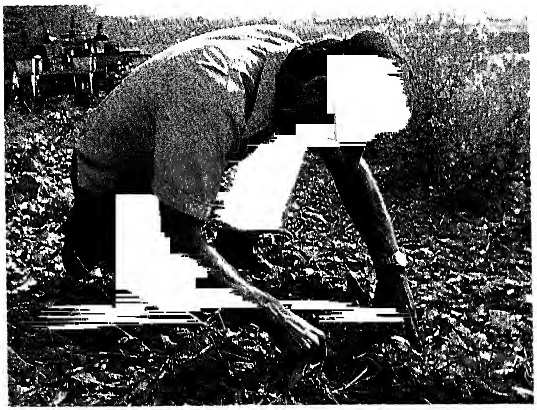


GENE ALEXANDER

For most farmers, work begins in the spring when more than 350 million acres of cropland are planted. Giant machinery allows them to farm many times more land in less time. One farm worker now supplies enough food and fiber for 68 people, a 30 percent increase over 10 years ago.

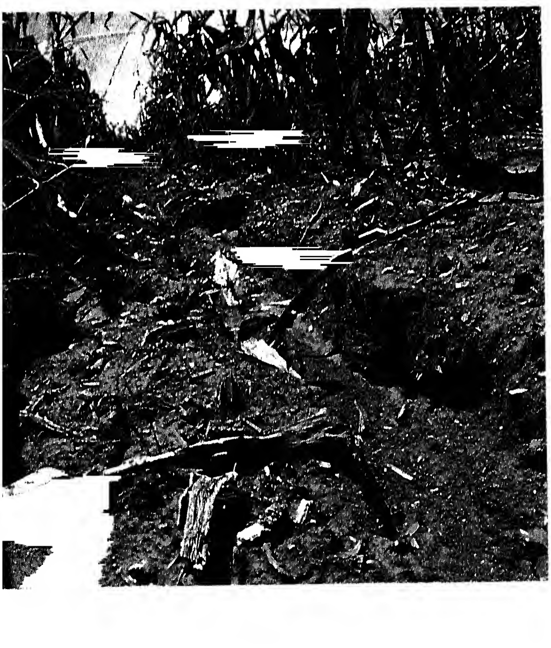
GENE ALEXANDER

Above, an Iowa farmer plants corn with a 16-row planter on terraced land. To the right, a Maryland farmer checks seed rate on land he is seeding to corn with a no-till planter. Following planting he will apply a herbicide to control weeds.



TIM McCABE

TIM McCABE

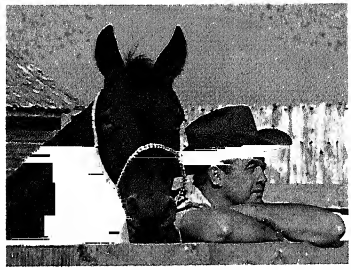


JOE LARSON

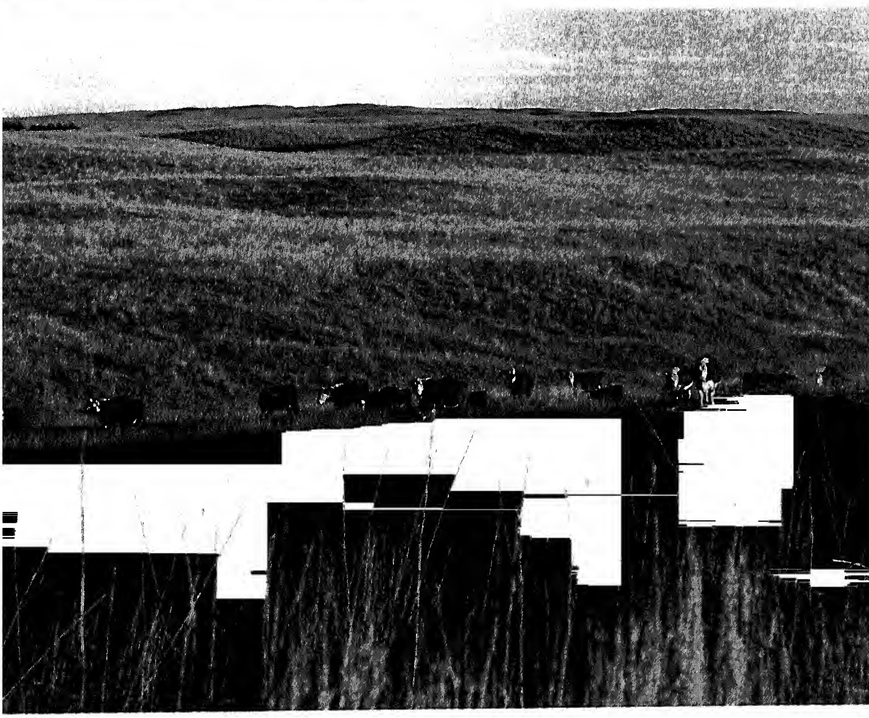
Conservation tillage — where row crops are planted in the residue of the previous crop — often eliminates the need for cultivation and reduces erosion. Soil erosion is a growing menace as more land is converted for row crop production.

The rich land and water resources of the U.S. feed not only Americans but also the people of other nations. Some question our ability to continue this in the long run.

GENE ALEXANDER



ERWIN W. COLE

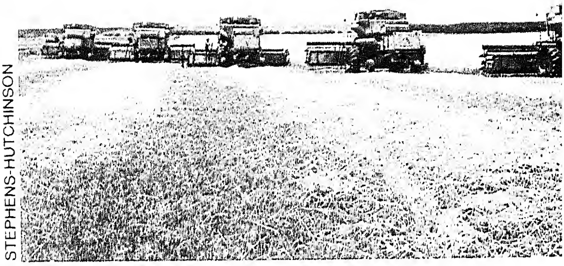


GENE ALEXANDER

Left, prime farmland is flat and fertile — the best we have for growing crops. It is also the easiest to develop for non-farm purposes, and therefore prime farmland is going out of agriculture at a disturbing rate.

Above, the Great Plains, a region of high risks and low rainfall, is known for its livestock, wheat, and rugged ranchers. From it comes 30 percent of our beef cattle and 60 percent of our wheat.

BART STEWART



STEPHENS-HUTCHINSON

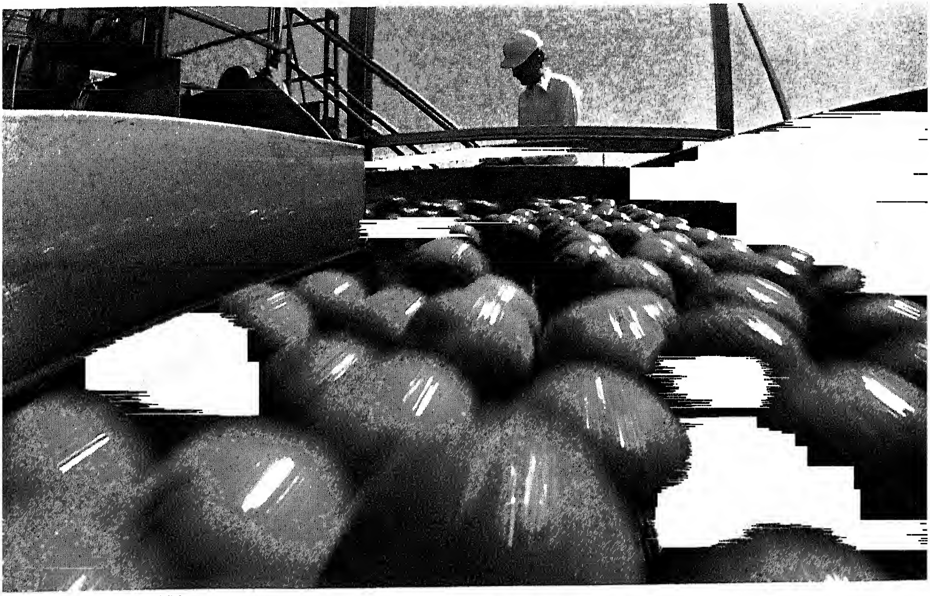
RUSS FORTE

At the left, wheat ripens in the Nebraska sun, and (above) combines move through the Great Plains States. Wheat is grown on about 70 million acres of land in the U.S. About one third is exported to foreign nations.

MURRAY LEMMON

In the past 20 years, average corn yields in the U.S. have jumped from 54 to 109 bushels an acre. This tremendous increase can be credited to research, improved farming practices, and excellent weather conditions.

GENE ALEXANDER

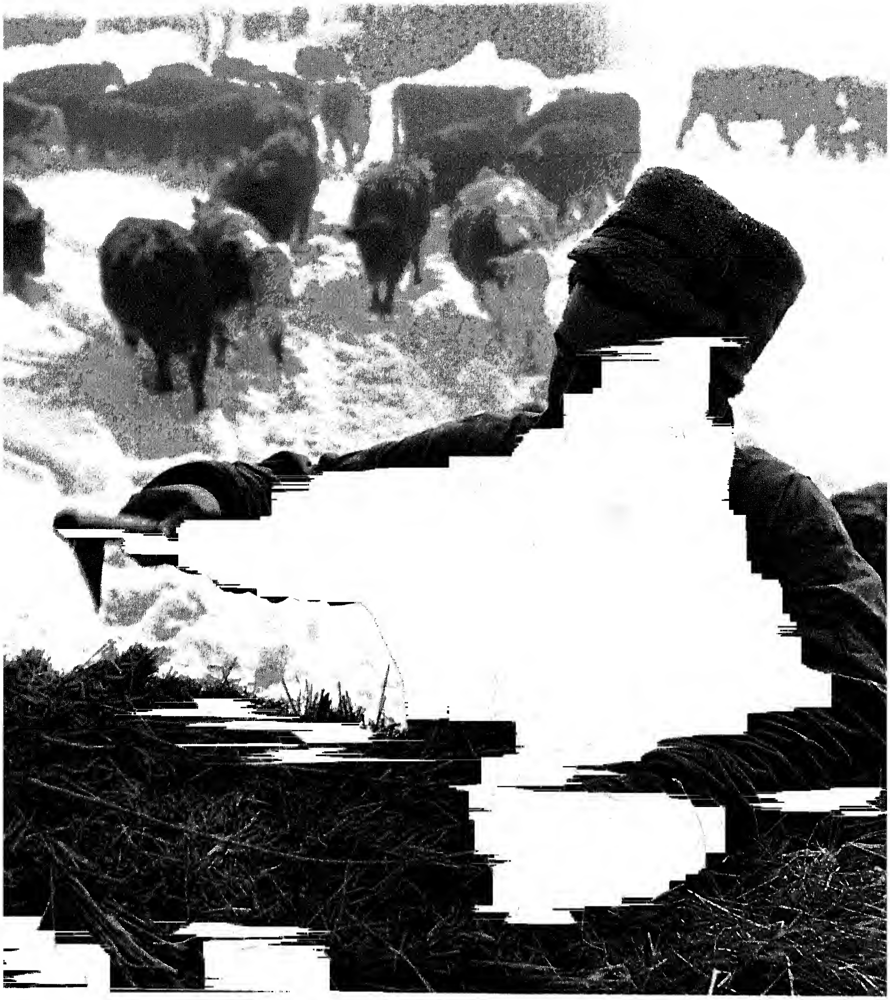


BOB LLEWELLYN

DON C. SCHUHART

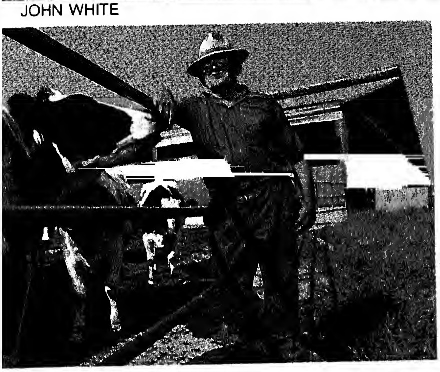
JOE LARSON

The U.S. produces a tremendous variety of food products such as cabbages from Florida, apples from Utah, and oranges from California.



Raising beef cattle is a year-round operation. A Colorado rancher hauls feed to his cattle during the winter and (right) a Missouri farmer checks his cattle for disease and infection.

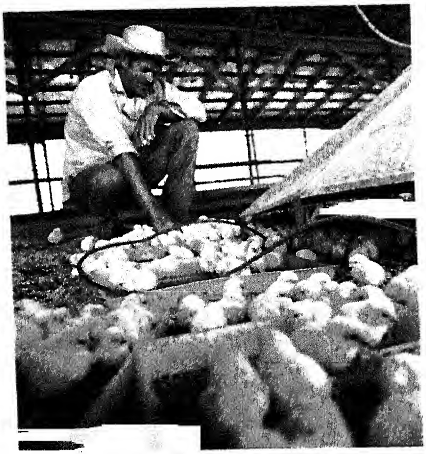
JOHN WHITE



TIM McCABE

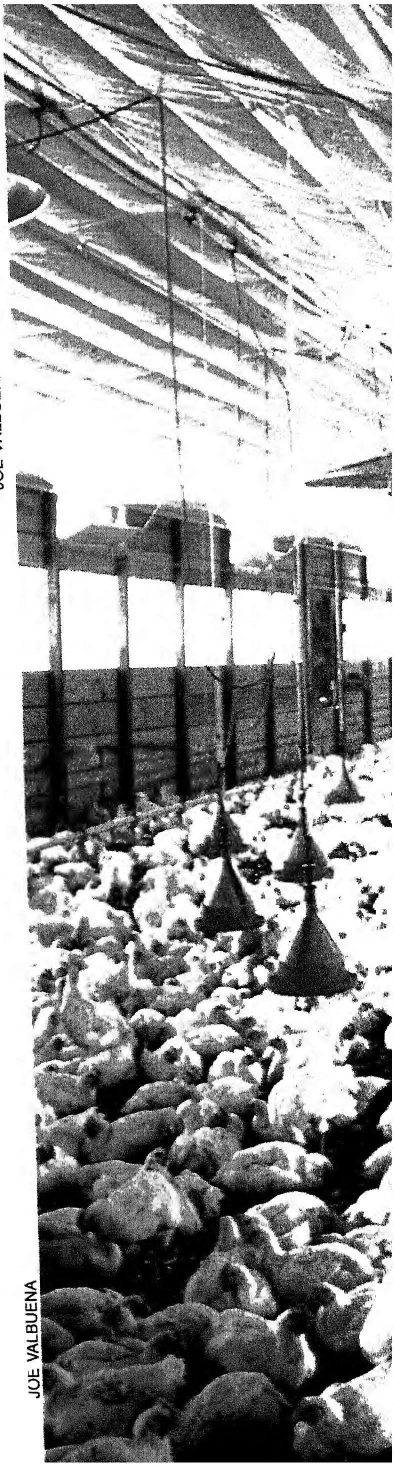
Branding cattle is a springtime chore on most cattle ranches.

A Pennsylvania dairy farmer pauses beside a portion of his 1,800-head Holstein herd. Probably more than any other type of farming, dairying is most demanding. Cows have to be milked two — sometimes three — times a day, every day of the year.

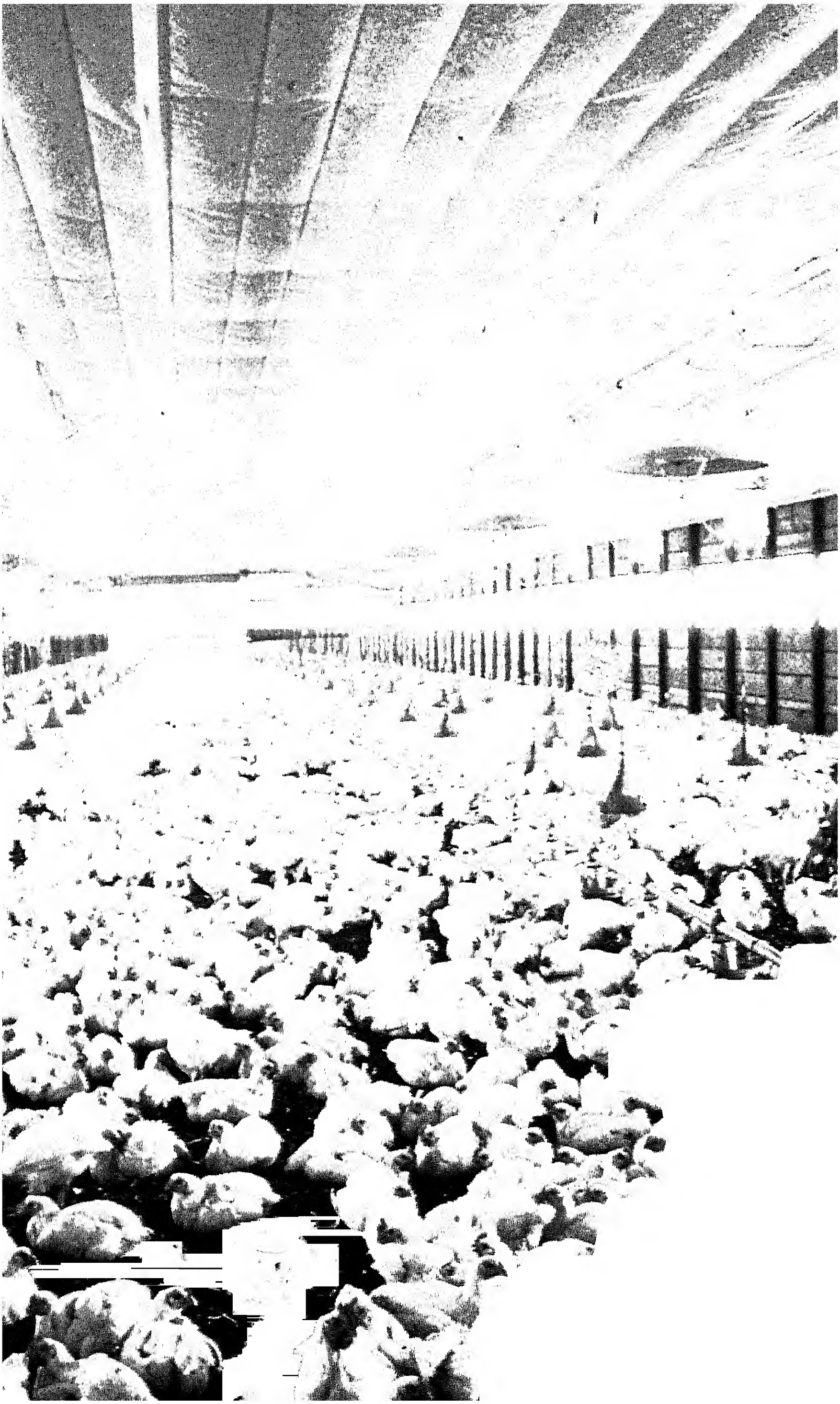


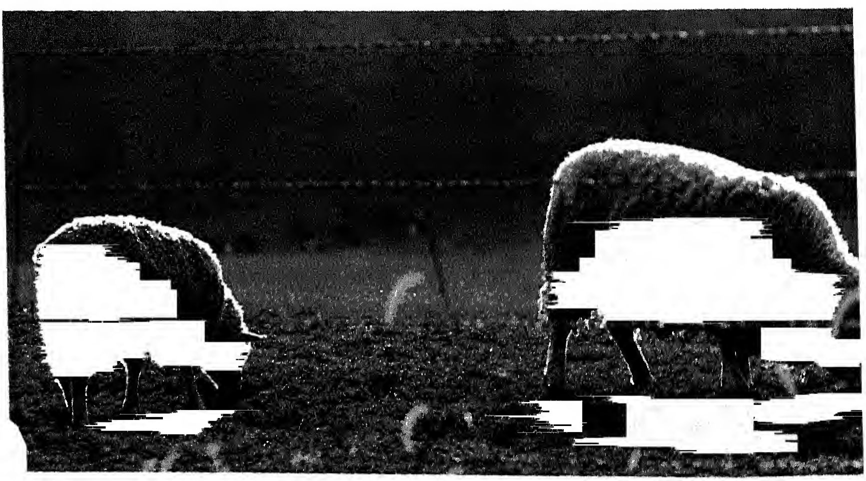
JOE VALBUENA

Day-old baby chicks are delivered from hatcheries to some 30,000 farmers who grow broilers for a living. While on the farm the chicks will increase their weight some 60 fold, from one ounce at hatching to 3¾ pounds at maturity — and that takes just 8 weeks. Chicken is an American favorite — the "average" American eats almost 40 pounds of broilers a year.



JOE VALBUENA

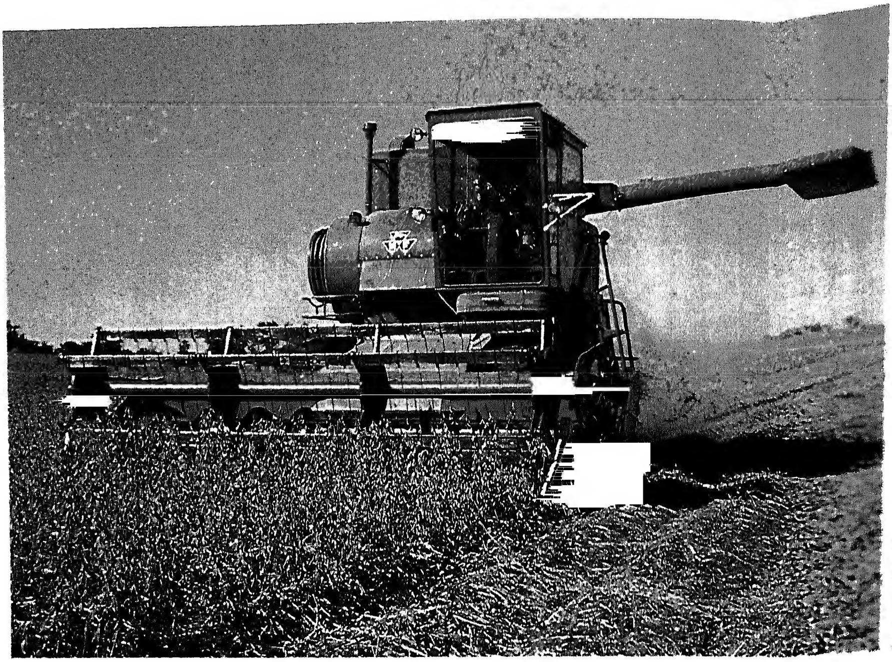





DANA DOWNIE


DALE MILLER

The Iowa hog farmer above produces enough each year to satisfy the pork needs of 9,000 people. Pigs go to market when about six months old and weigh about 200 pounds. Sheep are raised for both wool and meat. Farmers market about 8 million head a year.



CHUCK BEAN

BOB ELBERT

GRANT MANGOLD

BOB ELBERT

In this century, soybeans account for the single most sensational growth among major farm products, with an acreage increase from a million in 1930 to more than 70 million acres in 1979. Photographs show the young plant emerging, the beans beginning to fill the pod, and the mature bean in an opened pod.

Farmers harvested 2¼ billion bushels in 1979, making soybeans one of our more important export crops.

USDA

LLEWELLYN

C. OLIVIA CARLISLE

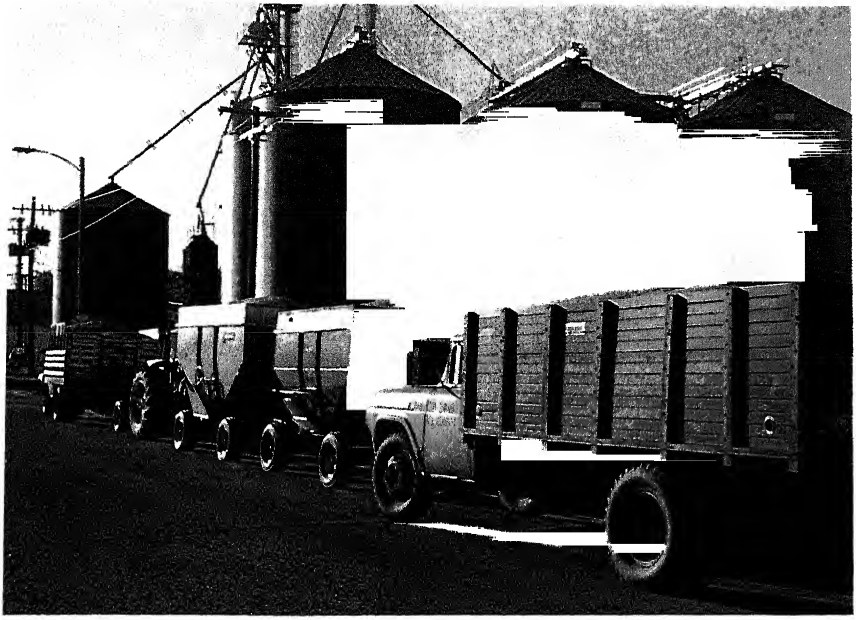
Opposite page: The problem of transporting, storing, and handling food products will grow dramatically in the future. Pictured is a portion of the Hunts Point Terminal Market in New York where 900 tons of fresh produce arrive every hour.

The largest share of the American food dollar is spent in supermarkets, and most meals are prepared at home. But there is a growing trend — especially when both spouses work outside the home — to eat more often in restaurants and fast food outlets.

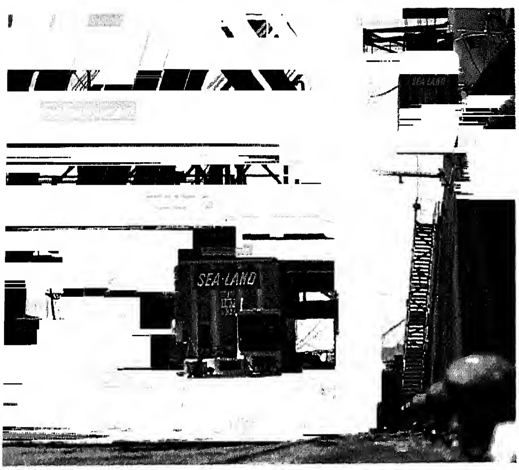
BOB ELBERT

MALCOLM W. EMMONS

Growing food is one problem. Getting it to where it's needed is quite another. The U.S. depends on trucks, barges, railroads, and ships. All are becoming more expensive or are being phased out. A great deal of U.S. food is now containerized — hauled partly by truck or rail and then loaded directy on ships.

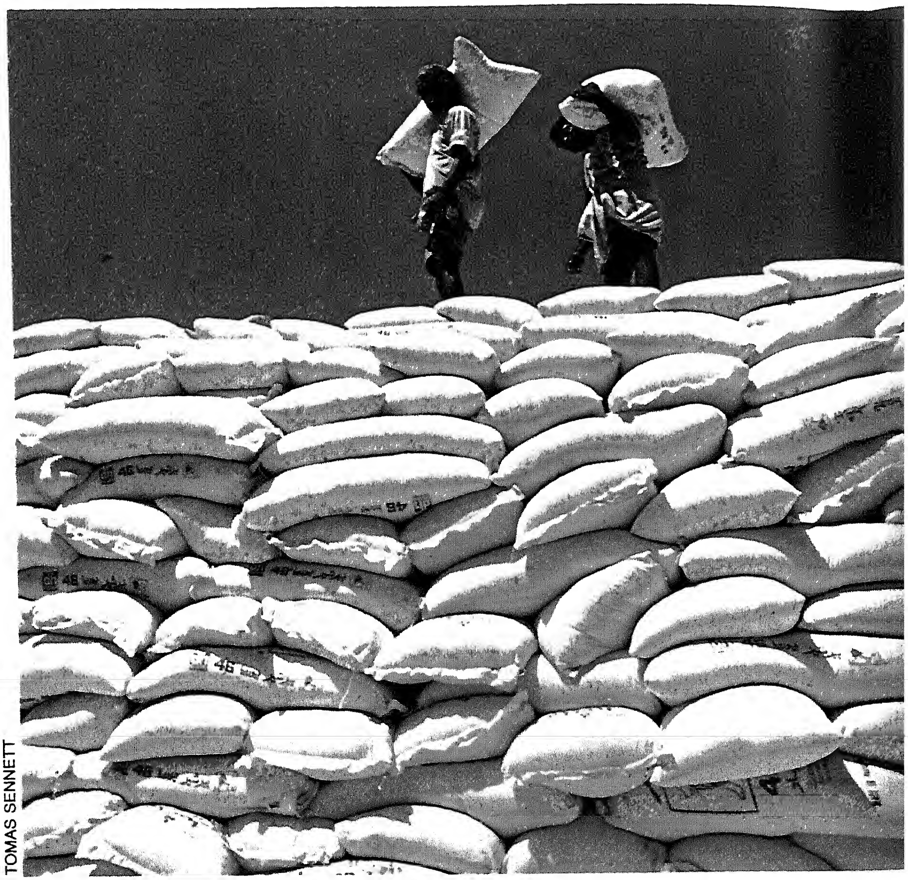


DON BRENEMAN



DAVE WARREN

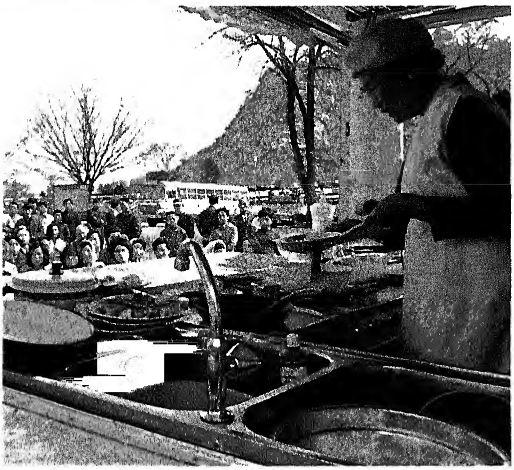
TOMAS SENNETT



The United States and United Nations offer various food-aid programs, especially to developing nations. Such programs are designed to improve the health and economies of these countries.

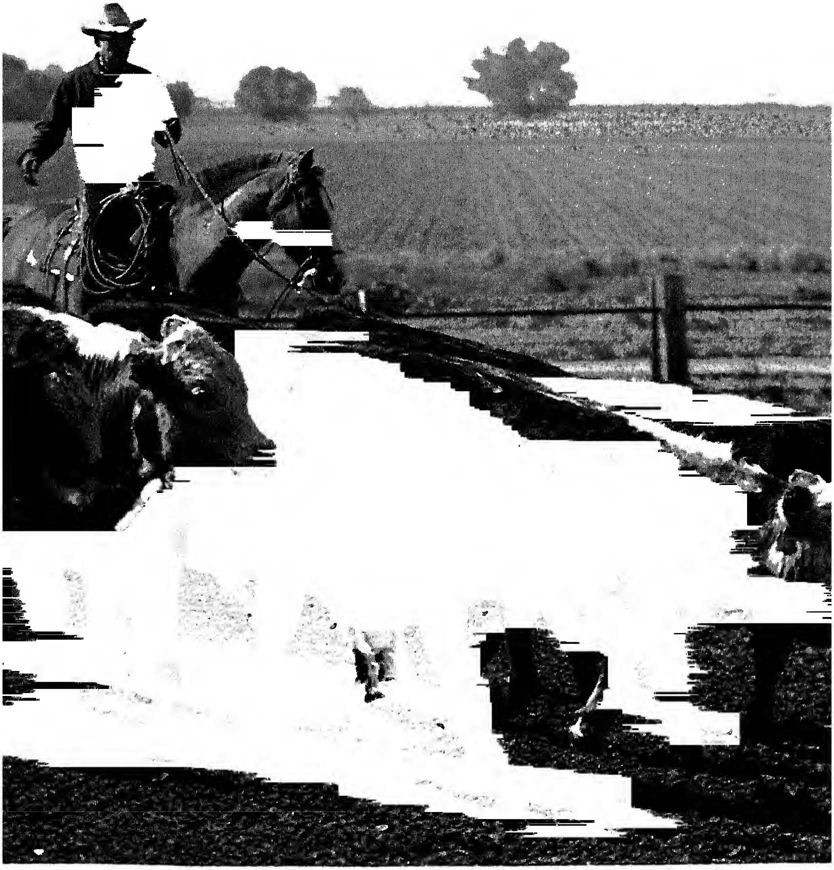
TOMAS SENNETT

CARL PURCELL



SOYBEAN DIGEST

The U.S. and other nations provide techincal help to many countries so they may become more self-sufficient in food production. In developed nations, USDA sponsors trade shows to encourage more sales of U.S. agricultural products abroad.



Agricultural research has an important role in the future of American farming. At the Meat Animal Research Center in Clay Center, Nebr., work is underway to find which classes of beef cattle produce calves that grow faster using less feed.

ROBERT BARCLAY

BRUCE FRITZ

BOB BJORK

A USDA horticulturist holds a potential orchard of apple trees that were produced in a synthetic growth medium. Below, gene transfer from one plant to another will enable scientists to develop plants that are insect and disease resistant and have more nutritive value.

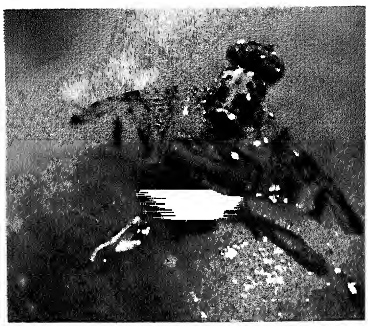
Below, a USDA scientist conducts experiments that may one day aid in developing grassy plants that fix their own nitrogen. At the right, USDA and NASA scientists work on landsat technology that some day will enable them to determine world crop yields by satellite.

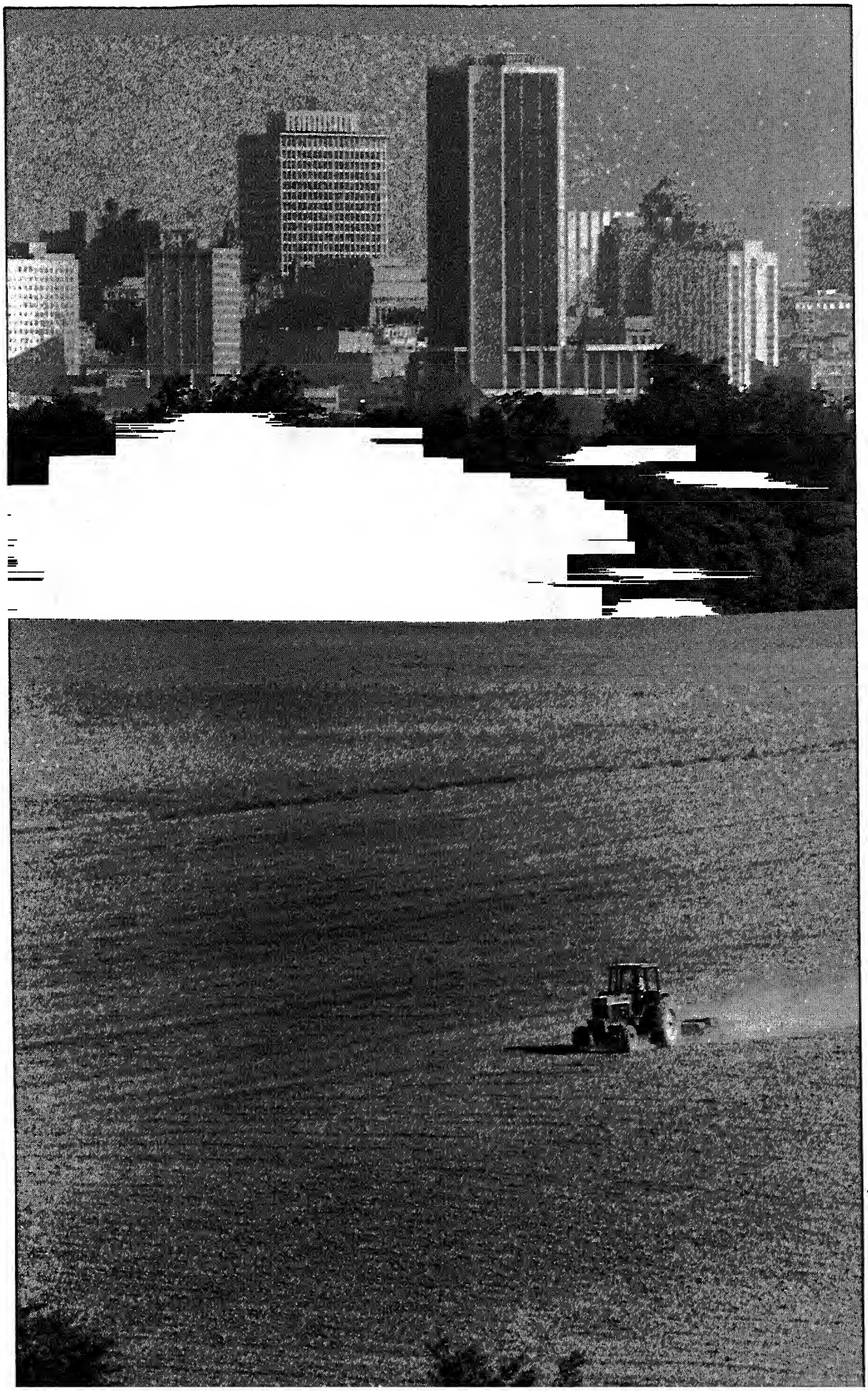
JOE AKER

ROBERT BARCLAY

Many beneficial insects are being used in the biological control of those insects that damage food plants. The seven spotted ladybird beetle has been introduced in many States to control harmful aphids.

Release of sterilized insects to compete with native insect populations has proven to be an effective weapon against some species. Above, a plane is being loaded with sterilized screwworm larvae for release over Mexico. Center, sterilized Mediterranean fruit flies (Medflies) are used after spraying operations in California. The Medfly, bottom, poses a serious threat because it lays its eggs in a variety of fruits and vegetables.





Foreword

Will there be enough food? Knife and fork economics means a lot to us all. We want plentiful, good food, reasonably priced. Yet we're quick to share our food with the hungry in our country and abroad.

Meals by the millions call for a productive, healthy agriculture — which in turn means jobs — jobs by the millions in factories and stores, in processing and storage, in finance and transportation, in laboratories and offices, in supermarkets and fastfood shops. Agriculture keeps the wheels of the economy turning.

Overseas, American food is major markets and a positive agricultural balance of payments. We sell much more food abroad than we buy from foreign nations. With the difference we can buy oil, minerals, and other non-food products that are used in every home.

But this isn't all automatic. And good times and good food today don't assure us that it will always be that way.

There are some questions to be answered and some problems to be worked on the land and in the food chain. Americans — farmers and non-farmers — need to face up to these if we're to keep doing a good job of feeding ourselves and helping to feed the world.

Which brings us back to that pesky question: Will there be enough food? It really depends on you — and others like you.

Read this book and find out about it.

John R. Block
Secretary of Agriculture

Preface

Jack Hayes
Yearbook Editor

This 1981 Yearbook of Agriculture shows how U.S. food production, besides filling our needs for good food, lines the pockets of countless Americans by providing more paychecks than any other industry. And U.S. food helps ease hunger — and discord — around the world.

The question, of course, is whether farmers and the rest of this marvelous mechanism can keep doing their job. Take time to read about this compelling issue in the Yearbook. Food for the body, food for the mind.

Secretary of Agriculture John R. Block personally chose the subject of this book. Spearheading those who got the book going were Chris Mosher, Assistant to the Secretary, and Claude W. Gifford, the Agriculture Department's chief information officer.

The book contains a variation of viewpoints.

Denver Browning served as the Yearbook's assistant editor, and compiled the index.

The 1981 Yearbook Committee planned the book. Wayne Rasmussen of the Economic Research Service was Chairman.

Members, by agency, were:

Agricultural Marketing Service — James Pearson, Harold Ricker
Agricultural Research Service — Mary Carter, Paul A. Putnam
Cooperative State Research Service — Richard Garner, Clare I. Harris
Economic Research Service — William D. Anderson, David Harrington, George Hoffman, Kathryn Zeimetz
Extension Service — Ovid Bay
Foreign Agricultural Service — J. Don Looper, Daniel E. Shaughnessy
Office of Budget, Planning, and Evaluation — Earle Gavett
Office of International Cooperation and Development — Dana Dalrymple
Office of Transportation — William A. Bailey
Science and Education — Gary Evans, John Stovall
Soil Conservation Service — Hubert Kelley, Howard Tankersley
Washington State University — Terence L. Day

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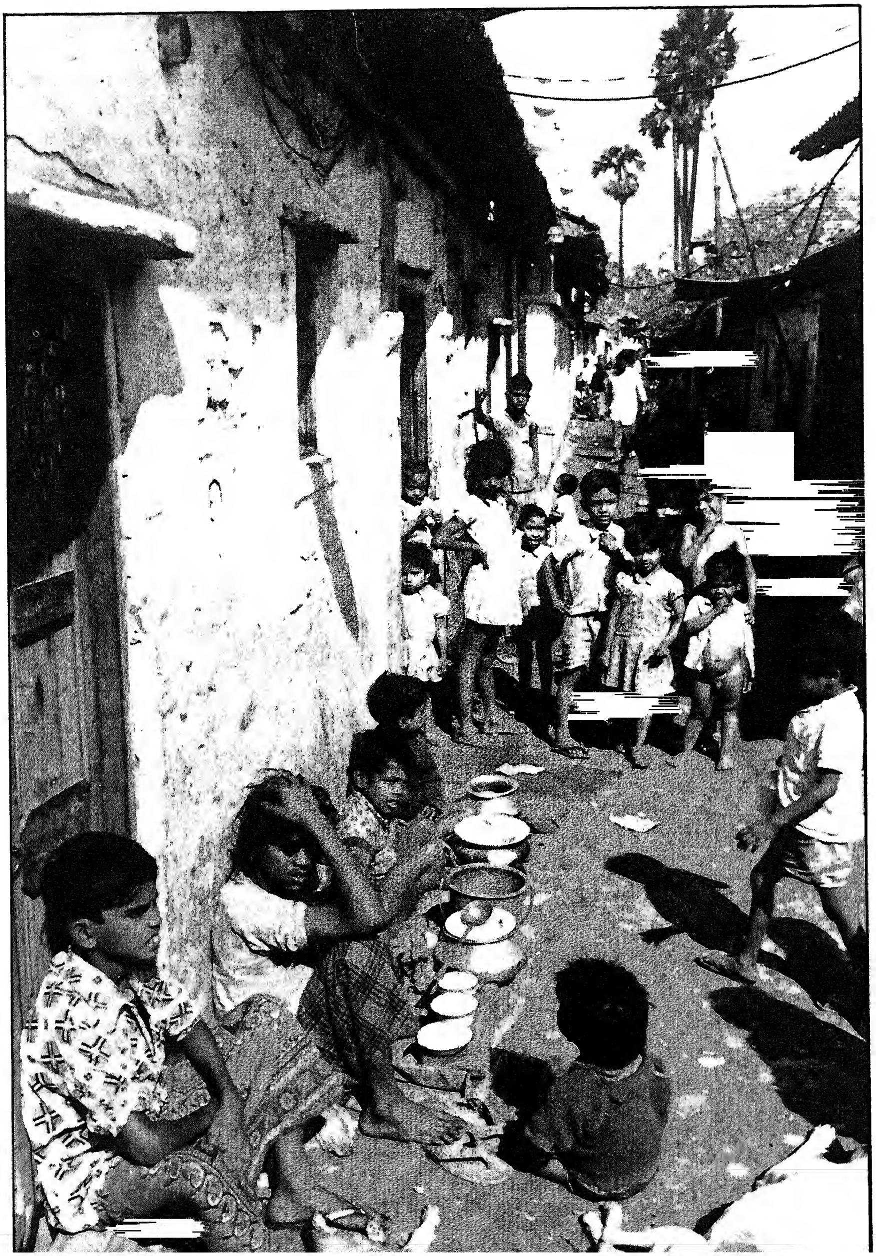
V. The World Outside

VI. Looking Ahead

Section One

Prologue: New Thoughts on an Old Subject



RAY WITLIN

Food, Famine, and a Realistic View

By J. Don Looper

To Americans, food is more than necessary. It is pleasurable, sociable, satisfying, perhaps fattening. But it is never scarce—at least not in the memories of Americans living today. Only in the last decade has the notion of world shortage begun to impinge in a consistent way on the national consciousness.

It is convenient if not altogether realistic to think of this change as dating from July 8, 1972. On that day the leaders of the Soviet Union agreed to a substantial purchase of U.S. grains. Actually they bought much more—spending $1.1 billion in one year instead of the agreed-upon $750 million in three years.

These purchases were dictated as much by Soviet political decision as by the crop shortfall in that country. Nevertheless that development, coupled with short crops in other parts of the world, sharply altered the global supply picture. These and subsequent events may also have permanently modified America's complacence with respect to food abundance.

In 1973, world crops returned to normal, although reduced stocks continued to be worrisome, leading to a short-lived but well-remembered U.S. embargo on soybeans and related products that summer. In 1974 an even more shocking event took place: America the Bountiful experienced a shortfall in autumn-harvested crops, the result of an unusually late spring, summer drought, and early frost.

The decline was relative—a corn crop down 17 percent from a record crop in 1973 and a soybean crop 21 percent below a 1973 output of enormous proportions. Nevertheless, these declines created uneasiness about U.S. supplies and nervousness about Soviet buying, especially of corn. This brought an official interruption in U.S. corn exports to the Soviet Union in the fall of 1974 and again in the summer of 1975.

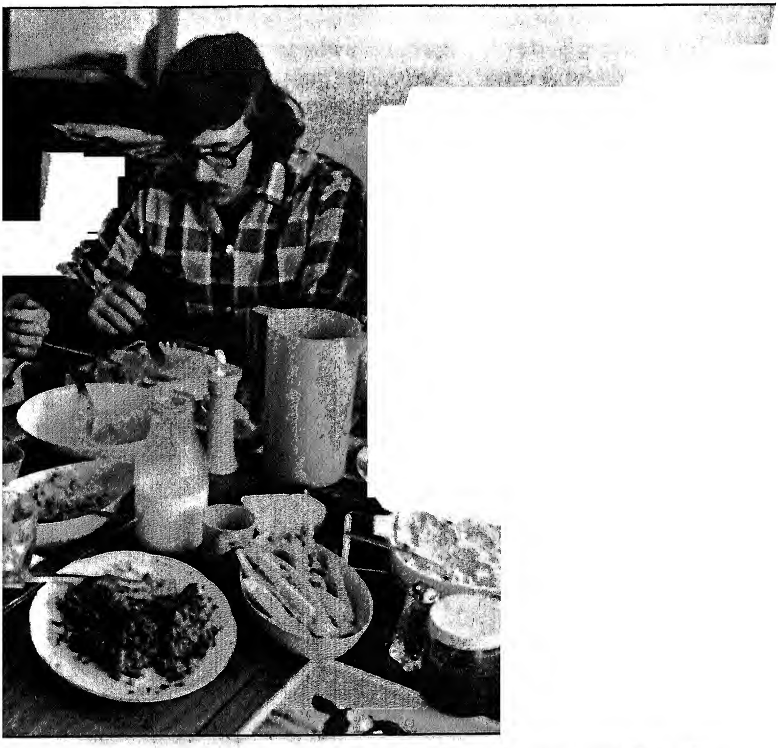
BOB BJORK

800 Reporters

Meanwhile, in November 1974, 130 nations joined in a U.S.-proposed World Food Conference in Rome. Whatever the lasting achievements of that Conference, one thing is sure: It was a roaring success as a media event, attracting 800 correspondents from all over the world and a host of non-governmental organizations promoting their assorted views.

The Columbia Broadcasting System ordered daily coverage on its television evening news, and other networks followed the CBS lead. In a 15-day period, world food subjects won front page treatment seven times in the Washington Post and 10 times in the New York Times. Those papers and a dozen other major metropolitan U.S. dailies sent staff reporters to Rome.

But that was enough. A two-year parade of human tragedy,



Americans have always been complaisant about food abundance, but world shortages in the 1970's began to change the thinking of many.

highlighted by a major drought in sub-Saharan Africa, had used up the video viewer's attention span. In this country, and worldwide as well, the public's concern about hunger began to moderate.

As 1975 moved toward harvest, food moved back to the farm page, and U.S. farmers returned to a more traditional concern—what to do with crops that promised to be bumper and prices that promised to be lower. Both promises came to pass. All U.S. farmers had to show for two years of famine hysteria was a 3-year decline in grain and soybean prices and a 30 percent decline in net income.

The world food situation improved steadily following the 1972-74 period—even when measured on a per capita basis. The United States set new production records for 5 consecutive years before experiencing another drought-affected setback in 1980.

Still, events of the 1970's had taken a toll on complacency, even among Americans long accustomed to thinking of food abundance as being permanent—as long as the sun shines and the Safeway stands on the corner.

Looking back, even an optimist had to recognize that, compared with the preceding 25 years, the 1970's were a decade of slower growth in world production and greater ups and downs from year to year. Of the nine years ending with 1980, world production had declined rather sharply in four.

Not everyone, moreover, is an optimist. The subject of world food inspires a wide divergence of views on world food questions at any given time. What is the likely extent of

New crop production records were set in the United States during the five-year period 1974-79.

How much of the responsibility for change should bear on the United States and other developed nations?

Gloom and Doom

Extreme views are always the easiest to explain and to dramatize. The pessimist can argue that:

1. World population continues to grow, and the world obviously cannot support a trend line that continues upward without end.

2. While per capita food production has risen since the declines of 1972 and 1974, this is mostly a reflection of improvement in developed countries. Per capita production is almost stagnant in the developing countries.

3. Most of the improvement in food consumption has stemmed from an expansion in trade—not from any general improvement in self-sufficiency in poorer countries. And the United States has provided most of the increase in trade. In ten years, U.S. exports of grains and oilseeds have doubled in volume.

4. The agricultural resource base is diminishing, and expanded production is increasingly taxing to soil and water resources. Most of the U.S. farmland held out of production in the 1950's and 1960's has now been returned to crops; meanwhile, farmland is being lost to other uses at the rate of 3 million acres a year.

5. The expansion in U.S. production since World War II is traceable to an explosion in the development and adoption of new research and technology, and we have now reached a scientific plateau. New developments comparable to hybrid corn, for example, will be few and far between.

Those arguments are heard in one At the other end of the spectrum is the "foodaplenty" school. Both the faminists and the plentyists can point to history in support of their arguments.

Famines are as old as the 12th chapter of Genesis, when Abraham went down to Egypt "and there was famine in the land." No doubt hundreds of famines have been lost to history, but the record of just the la thousand years is tragic enough.

In 1125 a famine reduced by hall the population of Germany. Hunga experienced unspeakable hardship 1505. England records a terrible famine in 1586. Germany had another famine in 1817, and in 187 72 Persia lost a fourth of its popul tion to hunger.

Some 10 million Chinese died of starvation in 1877-78. Famines in India took 3 million lives in 1769-' one and a half million in 1865-66, and a half million in 1877. In 1891- a Russian famine brought hardshi to 27 million people.

But these were food famines, caused by local or regional failures food production as a result of weat and/or pestilence. What the faminists are talking about now i the prospect of world famine resu ing from a global population that overruns our ability to produce fo That's what Malthus had in mind when he published his classic stu in 1798.

The Rosy View

The plentyist says the Malthus theory has never panned out. Th faminist says that one of these d Malthus will turn out to be right The plentyist says mankind will

accept that kind of inevitability—if there's a problem there has to be a solution—and he answers the faminist point by point:

1. Obviously the world must bring population growth under control—for many reasons—and it will do so helped by economic growth in the poorer countries. In 20 years, the world's annual population growth rate has fallen from 2 percent to 1.8 percent, with developed and centrally planned countries accounting for all of the improvement. The developed nations as a group have a population growth rate below .8 percent.

2. There is a huge potential for improved food production in the developing countries along with improvement in purchasing power.

Many of these countries have already shown gratifying progress—improving agricultural production and food consumption over the past decade and assuring greater supplies in years of production shortfall. They include India, Bangladesh, the Philippines, Argentina, Brazil, and Colombia—countries whose populations total almost one billion.

3. International trade, now accounting for less than 15 percent of the food consumed in other countries, may well increase in importance. This is all to the good, reflecting greater efficiency in production and improved variety and quality in the human diet.

The United States has the capacity and the need to substantially expand its agricultural exports, a recognized U.S. policy objective. In the short term at least, the United States is worried more about competition from other exporters than about its ability to meet export demand.

4. Those who belittle the opportunity to bring additional land into food production are underestimating the potential in the non-Communist world.

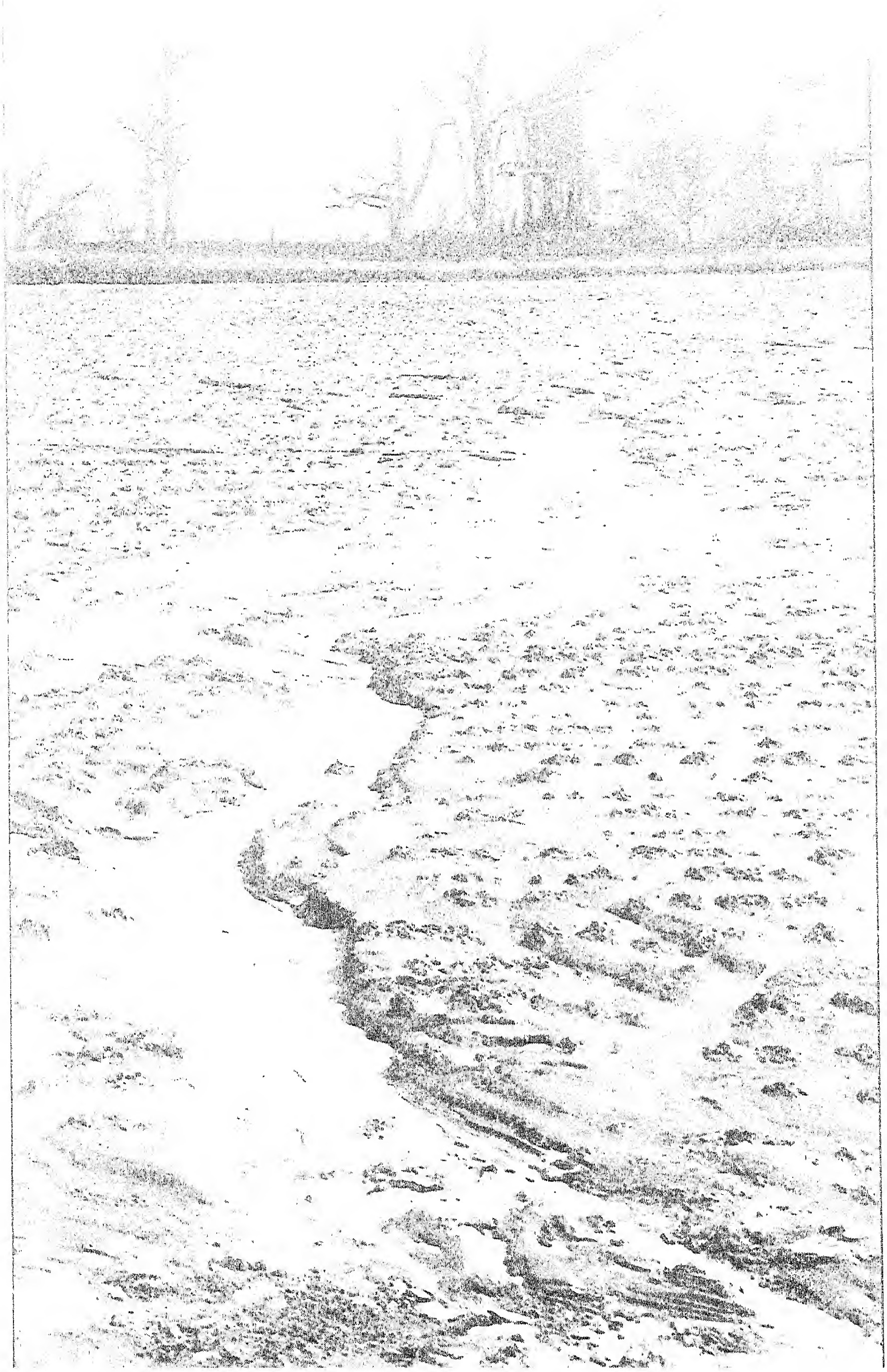
It may be true that Eastern Europe and the USSR have little potential for further expansion. But other developed countries and the developing world including China have a substantial opportunity to expand crop area.

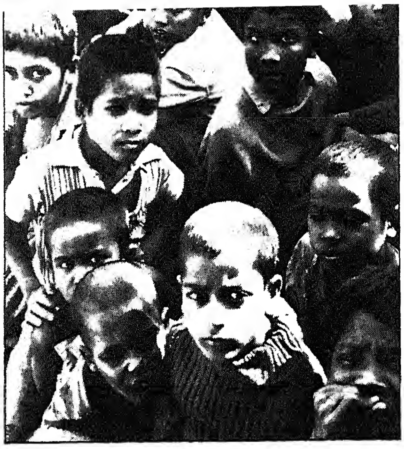
This is especially true in the Western Hemisphere and in tropical Africa. The United States, for example, has a cropland area of some 413 million acres with an additional 127 million acres identified as land of high and medium potential, according to the 1977 National Resource Inventory. With only some 360 million acres now being harvested, there is obviously additional land that could be brought into production given sufficient price incentives to farmers.

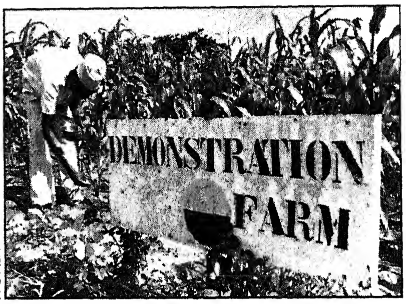
5. The argument that the scientific advances available to agriculture have now topped out resembles the 19th Century fear that "when we run out of whale oil, the world will be plunged into darkness." Actually, the pace of scientific innovation is accelerating to the point of mind-bogglement, and many of these advances will affect food production. Perhaps the most obvious implications are in the science of biotechnology, with its potential for modifying plant and animal heredity. But microscience, materials research, solid state electronics, and other avenues of research also promise new tools for progress in the food sciences.

Most Americans can find a place

Continued demand for agricultural exports could diminish our resource base by accelerating soil erosion and depleting groundwater supplies.







WORLD BANK

Since the U.S. cannot feed the world, ways must be found to increase production within developing countries — possibly through accelerated technical assistance.

between these polar positions. The most optimistic of us must recognize that the world faces serious food problems requiring the best efforts of the best minds in many disciplines. The most pessimistic of us will realize that these forces are already at work, that people are problem-solving animals, and that they are accustomed to winning.

Focus on Trade

Especially in America, the coming decade will see increasing attention to the effects of agricultural trade on the Nation's land and water resources and the environment.

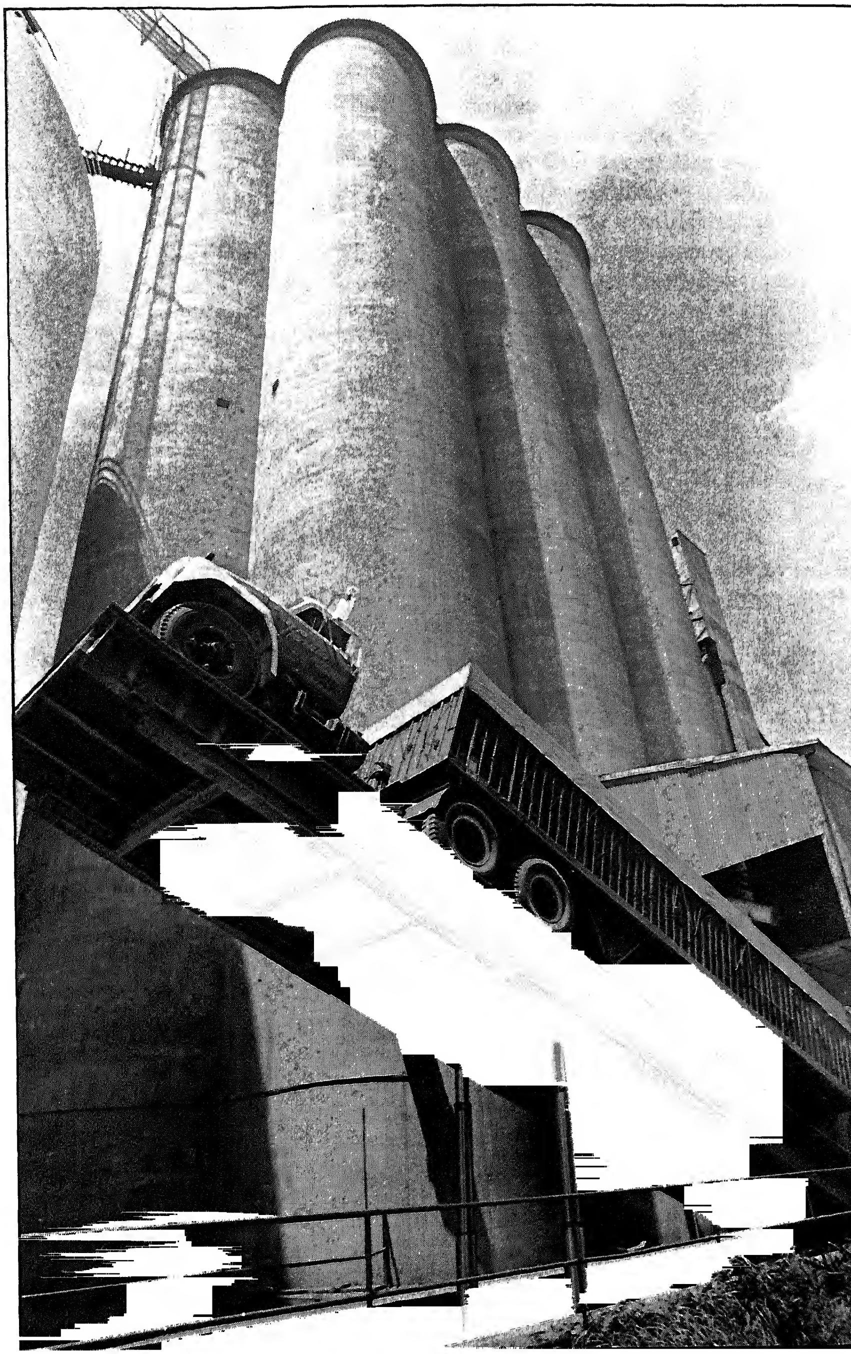
Federal and cooperative efforts in research and conservation are being intensified to assure future productive ability and resource protection without sacrificing the production of food that the world needs and the United States needs to sell. After all, if we should stop exporting, all the cropland in eight Midwestern States could be turned into one vast national park—with entrances near Cleveland, Kansas City, and Grand Forks, N.D.

Overseas sales are a key element in the improvement of U.S. agricultural income, the general economy, and the Nation's international economic position. Conversely, improved farm income—the price incentive—is a key to greater food production in the future, an assured source of supply for American consumers, and the continued application of sound conservation practices on the land.

In any case, American agriculture can not feed the world. The export of U.S. crops will continue to be essential, but by no means can it become the total solution to the world food problem. Ways must be found to expand planted area, increase yields, and improve the quality of food produced within the developing countries. Ways must be found to manage, store, and distribute these products to the end that they actually find their way into hungry stomachs.

As in America, this will require incentives to those who do the work and take the risk. That may be what the subject of food is mostly about—incentive.

Author J. Don Looper is Director, Information Division, Foreign Agricultural Service.



Farming and U.S. Well-Being Through the Years

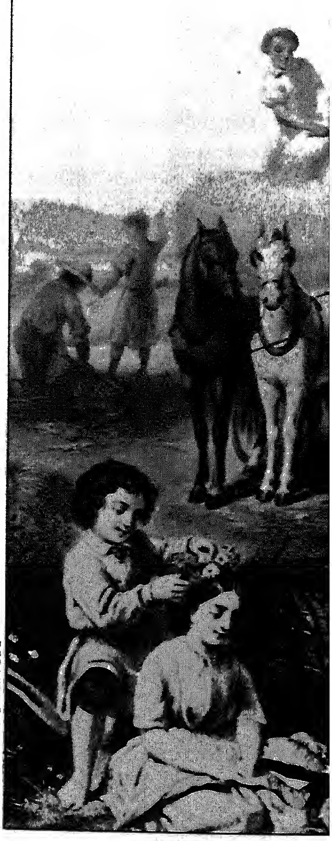
By W.B. Sundquist

Almost 375 years have passed since the initial settlement of the Virginia Colony on the Jamestown Peninsula in 1607. And, throughout this period, U.S. agriculture has played a key role in the well-being of our Nation's population.

Colonial agriculture was a rugged hand-labor process because the machinery and equipment to ease the burden of labor had not yet been invented. Moreover, primitive transportation and communication systems of that day made an organized marketing system for farm products virtually impossible. As a result, most people were involved in some kind of agricultural production if only to produce some of the food they needed for their own survival.

By early in the 17th century, U.S. agriculture had accepted what were to be its dual long-term roles of (1) feeding a growing local population and (2) producing goods for trade and export.

Borrowing from the know-how of the local Indians and using the crude tools available to them, colonial farmers produced corn as their staple food crop and tobacco for export. Virginia, Maryland and North Carolina led the way in production of tobacco, while corn was grown throughout the Colonies. Later on Southern plantation growers added rice and cotton to their list of export crops. Other cereal grains and livestock products soon augmented corn in the local diet and, by 1700 or so, these products



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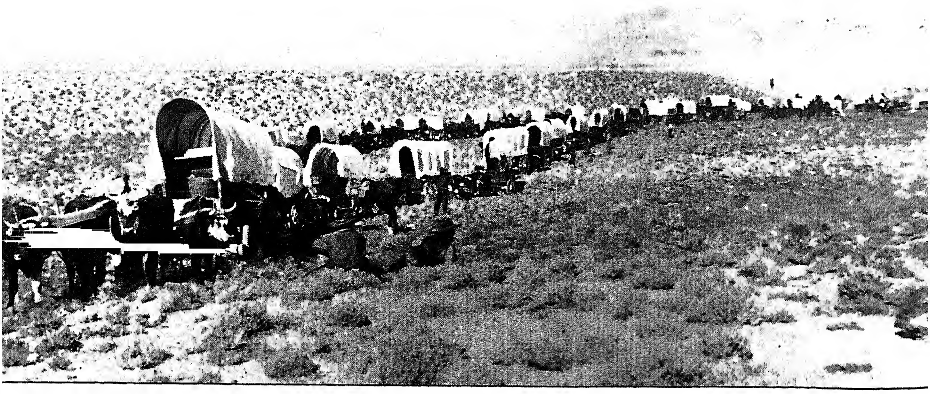
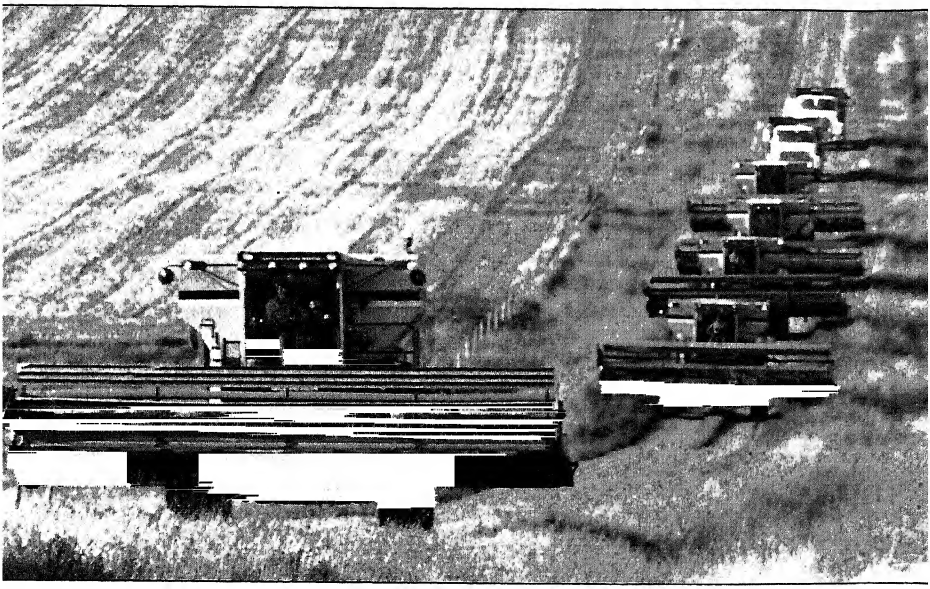
; romanticized American agriculture. In reality it required
·ugged hand labor. Transportation and communication
primitive.



As a result of the Homestead Act, farmers migrated from the East to establish agriculture as a viable industry in the West.



During the 1900's machine-power rapidly replaced manpower on America's farms and ranches. In 1880 it took 373 hours of labor to produce 100 bushels of wheat. Today it takes less than 10.

until the drought and depression of the 1930's that both reversed direction to begin the sharp decline to their dramatically lower current levels.

By 1979 the farm population of 6.2 million represented less than 3 percent of the total population, or only about 1 person in 35. And farm numbers had dropped to 2.4 million, or only slightly more than one-third of their all-time high in the mid 1930's.

Not all of these farm people left agricultural pursuits voluntarily, however. Many were driven out by inadequate resources and low incomes. Others were displaced by such technologies as the mechanical cotton picker, the tomato harvester and others. Those farms which remained grew in size, in productivity and in technological sophistication in order to provide food and fiber for rapidly growing domestic and foreign markets.

Labor Use in Farming

The tremendous gains in agricultural labor efficiency during the past century can be quickly perceived by viewing the labor requirements for producing key crops in 1880 and again in the 1970's.

In 1880 U.S. farmers used 180 man hours of labor to produce 100 bushels of corn through harvest. This requirement had dropped 44-fold to only 4 hours by 1974-78.

Comparable labor requirements for wheat were 373 hours in 1880 and 10 hours in 1974-78, a 36-fold reduction, and the labor requirement of more than 300 hours to produce a bale of cotton in 1880 dropped by 27-fold to 11 hours in 1974-78.

Though smaller percentage-wise than for field crops, major declines in labor requirements also occurred in the livestock sector. Chicken broiler and turkey producers led the way with declines of over 2,000 percent in man-hour requirements per hundredweight produced between 1940 and 1970 alone. And major gains in labor productivity were made for swine and dairy production and for cattle feeding.

These tremendous increases in labor productivity in agriculture were not achieved without a cost, however. New technology had to be developed in the Land Grant Universities in the U.S. Department of Agriculture (USDA) and in the private agribusiness sector. Farmers had to adopt this technology and learn how to use it. Moreover, farmers had to substitute large quantities of capital for labor. Many, unable to make this adjustment, left farming.

Input Mix in Farming

In 1880 labor represented an estimated 62 percent of the total inputs (value weighted basis) used in U.S. agriculture and real estate and capital inputs totaled 19 percent each. By the beginning of World War II the labor input had declined to 40 percent of the total, capital had risen to 41 percent and real estate had remained relatively constant at 18 percent.

But the most rapid change in farm inputs was to come after World War II. By 1976 labor had declined to 16 percent of total inputs, real estate increased slightly to 22 percent and capital had jumped to 62 percent.

Thus, over the period of the last century, production agriculture shifted from a labor intensive production sector to a capital intensive one.

Excluding farm real estate, the capital component of agriculture in 1880 was made up mainly of machinery, feed, seed and livestock. Purchased inputs were used only sparingly by farmers and agricultural chemicals were almost nonexistent. The widespread use of agricultural chemicals (particularly fertilizer and pesticides) is, in fact, mainly a post-World War II phenomenon as the index of their use increased more than eight-fold between 1945 and 1979. And mechanical power and machinery inputs more than doubled during this same period.

Thus, adjustments in the post-World War II mix of farm inputs have been heavily to purchased inputs, and the farm machinery and agricultural chemical industries have grown rapidly to become major economic sectors in their own right. These adjustments were clearly induced in no small part by cheap fossil source energy and by the rising real cost of labor. They have resulted in a high degree of oil dependence by U.S. agriculture.

The Farming Business

In the process of becoming a capital intensive economic sector, agriculture has taken on many characteristics of other "value-added" economics sectors with high capital expenditures, both for long-term investments in plant and equipment (feedlots, machinery and power, irrigation equipment, etc.), and for short-term operating expenditures (fuel, fertilizer, chemicals, etc.).

Along with the tremendous shifts in input mix in farming there has been an increase in size of farms and in degree of specialization. Average acres per farm about doubled to over 400 acres between 1950 and 1979 alone. The size of "operating units" increased much more. Most family-scale commercial farms now utilize capital resources (including real estate) of $500,000 or more. And, a resource base of $2 to $3 million is not unusual. Moreover, in 1979 farms with sales of $200,000 and over accounted for 43 percent of all cash receipts. Thus, farming today is big business.

As a consequence, farmers are now concerned with many of the same investment decisions and cash flow problems of other businesses. Moreover, they share with other businessmen the uncertainties of the market place for their purchased inputs and for their final products. This uncertainty has sped the formal integration of the input supply-production-product marketing stages in agriculture.

In addition, however, farmers find themselves faced with a rather unique set of exposures to 1) the biological processes of plants and animals, and 2) the natural environment, with their attendant complex risks and uncertainties of diseases, insects, droughts, hailstorms and the like. Moreover, in order to survive economically, farmers have had to add high-level financial management skills to go with those of increased technical expertise.

Farm Output Changes

Farm output in the United States doubled in the 50 years from 1880 to 1930. And 1979 found farm output about 2½ times its 1930 level. While most of the increase in output prior to 1930 was due to farming additional land, almost all the post-1930 increase is attributable to other

PAUL HIXSON

Soybean production in the U.S. rose from one million acres in 1930 to more than 70 million acres in 1979, the greatest growth among major farm products.

sources. In fact, the 348 million acres of crops harvested in 1979 were about 6 percent fewer than those harvested in 1930.

Most categories of agricultural products grew in volume over the century of 1880-1979 though the production of some, such as cotton, varied greatly during that period. Between 1910 and 1979 alone, dairy production doubled, meat animal production increased by almost 150 percent and poultry products grew by over 400 percent. On the crops side, feed grain production almost tripled and food grain production more than quadrupled.

But the single most sensational growth among major farm products occurred for soybeans. The soybeans for bean acreage in 1930 totaled only about 1 million with a total production of about 14 million bushels. In 1979, acreage exceed 70 million and production exceeded 2¼ billion bushels!

The rapid growth of the soybean crop was undergirded by a much expanded demand from both 1) the modernizing livestock sector for

high protein feed supplements, and 2) the human food sector for edible vegetable oils. Thus, when provided economic inducements to do so, U.S. farmers have been able to make major shifts in farm production, particularly for field crops.

In colonial days much of a farmer's production went directly into consumption on the farm or in the local community. By 1840, an extensive canal system moved some farm produce to markets but at a high per unit cost.

Rail Network

By 1860, a railroad network linked the country east of the Mississippi. And by the end of the 19th century a rail transportation system was largely in place to move agricultural produce to distant domestic and foreign markets or to intermediate points for processing or storage.

This transportation system was among the early components of what was to become a major off-farm agribusiness system. Initially these businesses were mainly involved in the processing and marketing of farm products. Later, the farm supply businesses were to grow tremendously as farmers purchased more and more of their inputs from off-the-farm.

A century ago a very high proportion of total employment in the United States (about 50 percent) was in agriculture. Gainful workers in agriculture totaled 8.6 million persons at that time and most were employed on the farm, since the complex modern-day marketing and food processing systems were yet to evolve.

As of 1978, however, agriculturally related employment had grown to about 22.4 million, of whom only 3.4 million were employed in production agriculture. In addition, 7.2 million persons were employed in agriculturally related transportation, trade and retailing; 4.8 million in manufacturing; 1.7 million in food processing; and 2.2 million in resource and service jobs related to agriculture. This aggregate employment in 1978 represented about 22.3 percent of the total U.S. labor force.

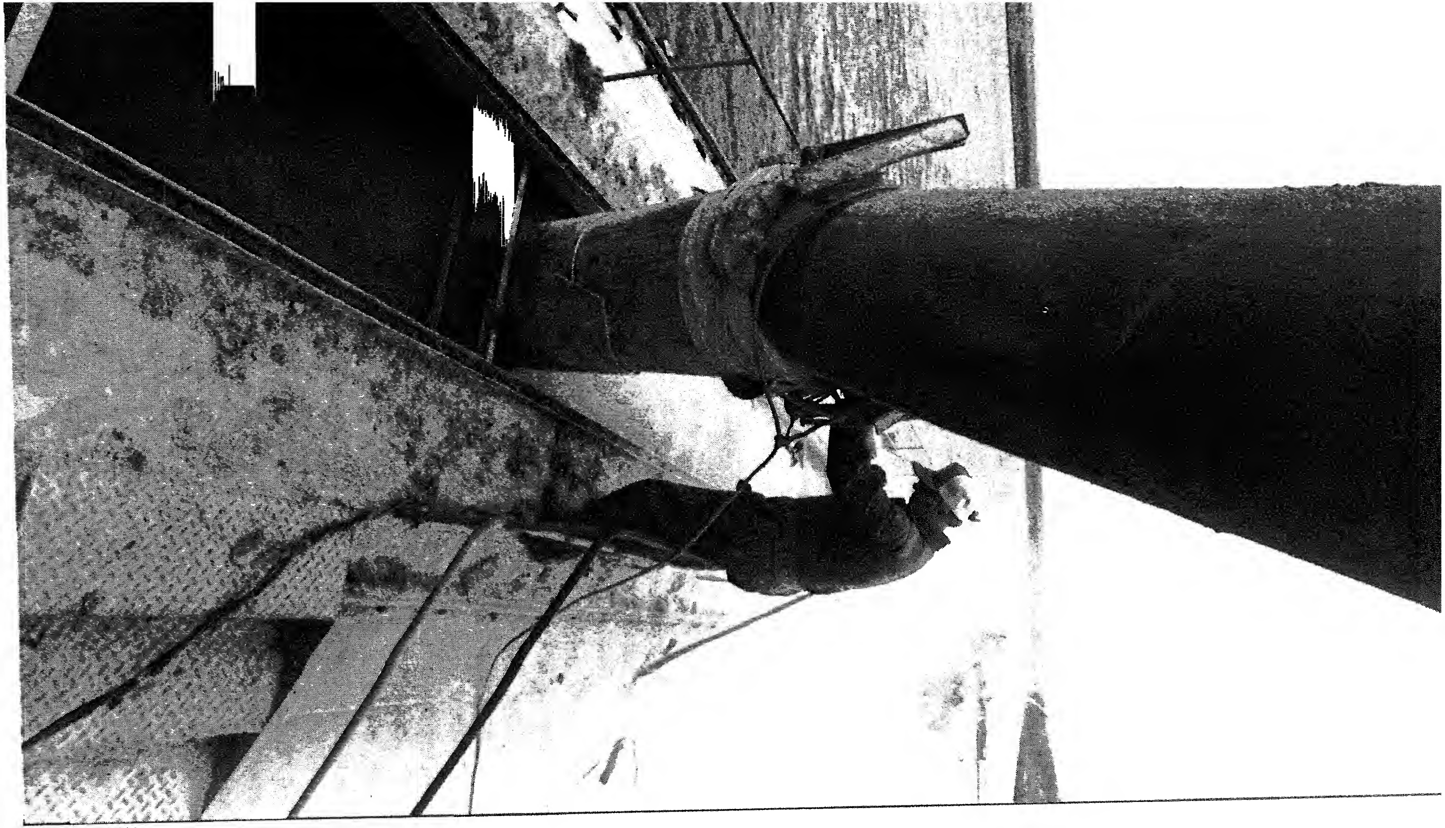
By 1978 the estimated bill for marketing domestic farm foods alone had grown to $140 billion, or more than two-thirds of the $207 billion which consumers spent for these foods.

Production agriculture has cut its labor force dramatically. But between 1968 and 1978 alone, marketing workers handling food produced on U.S farms increased by over 30 percent with away-from-home eating establishments being the single most rapidly growing component of the food marketing system. The cost of labor remains the largest component (often around 50 percent or more) of the cost of transporting, processing and distributing food.

A century ago, in 1880, agricultural products dwarfed those from other sectors in their economic importance in U.S. trade. Totaling $694 million, agricultural exports were 84 percent of the value of total domestic exports.

But the U.S. economy grew rapidly in its production of non-agricultural goods. And, though growing in total dollar value over time, agricultural exports declined to 62 percent of total exports by 1900, to 32 percent by 1930, and to 16 percent by 1970.

In 1979, the United States exported more than a third of its total agricultural production.


DOUG WILSON

In 1970 agricultural exports totaled about $6.7 billion. Then, following the tight supply-high price situation for grains on a world-wide basis in 1973-74 they moved up sharply to over $40 billion and to about 20 percent of total U.S. exports in 1980.

Exports A Beacon of Hope

In a generally bleak current trade-balance situation for the United States, the trade-balance surplus generated by agricultural products stands out like a beacon of economic hope. This trade balance is evidence of the strong comparative economic advantage of U.S. farmers in world production of grains and soybeans.

In fact, in 1979 the U.S. share of world soybean exports was 82 percent; for coarse grains, 67 percent; for wheat, 41 percent; and for cotton, 37 percent. Of the 164 million metric tons of U.S. agricultural exports in 1980, feed-grains led the way volume-wise with 72 million metric tons, wheat (including flour) was next with 37 million metric tons, and soybeans were third with 24 million metric tons. The United States, in exporting over one-third its total agricultural production in 1979, exported over half of its wheat, rice, soybeans and cotton production.

U.S. imports of agricultural products totaled $315 million or 47 percent of all imports on a value basis in 1880. Though increasing on a total current-dollar basis over time to a total of $17.4 billion in 1980, they represented only 7 percent of total U.S. imports in that year, leaving a net favorable trade balance in agricultural products of between $23 billion and $24 billion. Moreover, a substantial proportion of agricultural imports were of products such as coffee, tea, bananas, and other products not grown in the United States.

One measure of the strong economic performance of U.S. agriculture over the past century has been its ability to provide food for domestic consumers at decreasing real prices. Limited data for the period 1888-1891 indicate that consumers spent about 40 percent of their income for food at that time. During the period of 1930-1960 this percentage ranged from 20 to 24 percent. But from 1971 to 1980 the proportion of total disposable personal income spent for food dropped to a range of between 16.2 and 17 percent.

Costs to Consumer Cut

Thus the U.S. agricultural system has provided a broad variety of food to consumers at decreasing real cost. And along with this food, today's consumers receive much more in the way of services (processing, packaging and preparation) than did their counterparts in 1880.

Some individuals and families in the United States even today have inadequate income for food purchase Some others, either by ignorance or personal choice, have a diet which is inadequate nutritionally. And some issues of food safety and nutrition exist which will not be solved immediately. But U.S. agriculture has demonstrated clearly its capacity to produce food not only to service the food requirements of domestic consumers but for an increasing number of foreign consumers as well.

Any statistical depiction of the developmental history of U.S. agriculture will be deficient in its enlightenment. It cannot capture adequately the human struggle of the people involved or the signifi-

cance of key individual events. For that reason several generalizations may be warranted in restrospect.

First, U.S. agriculture was richly endowed with natural and human resources. The strong natural resource base of land, water and climate permitted a productive agriculture to evolve. An industrious, productive labor force was enticed into using these resources.

Second, an effective infrastructure of public services (research, education, governmental institutions, etc.) evolved to support the productivity of the land and labor inputs in agriculture.

Third, the private sector, in the form of small businesses, corporations and cooperatives, played a key role in supplying agriculture with needed production inputs, marketing services and applied technology.

Much of the support system supplied to agriculture by both the public and private sectors was not systematically planned in advance but was induced by economic crisis or financial incentive and implemented by human ingenuity or political pressure. Yet, in accomplishment, this total agricultural system has far outpaced that of most other countries. And we are all the beneficiaries of it.

Further Reading

A Chronology of American Agriculture 1776-1976, ESS Publications, U.S. Department of Agriculture, Room 0054-S, Washington, DC 20250. Free.

Ecomomic Indicators of the Farm Sector: Production and Efficiency Statistics, 1979, Statistical Bulletin 657, ESS Publications, U.S. Department of Agriculture, Room 0054-S, Washington, DC 20250. Free.

Historical Statistics of the United States, Colonial Times to 1970, #003-024-001-20-9, U.S. Department of Commerce, Bureau of Census, for sale from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. $26.

The Development of American Agriculture: A Historical Analysis, Willard W. Cochrane, University of Minnesota Press, 2037 University Avenue, S.E., Minneapolis, MN 55414. $10.95 paperback, $25 hardback.

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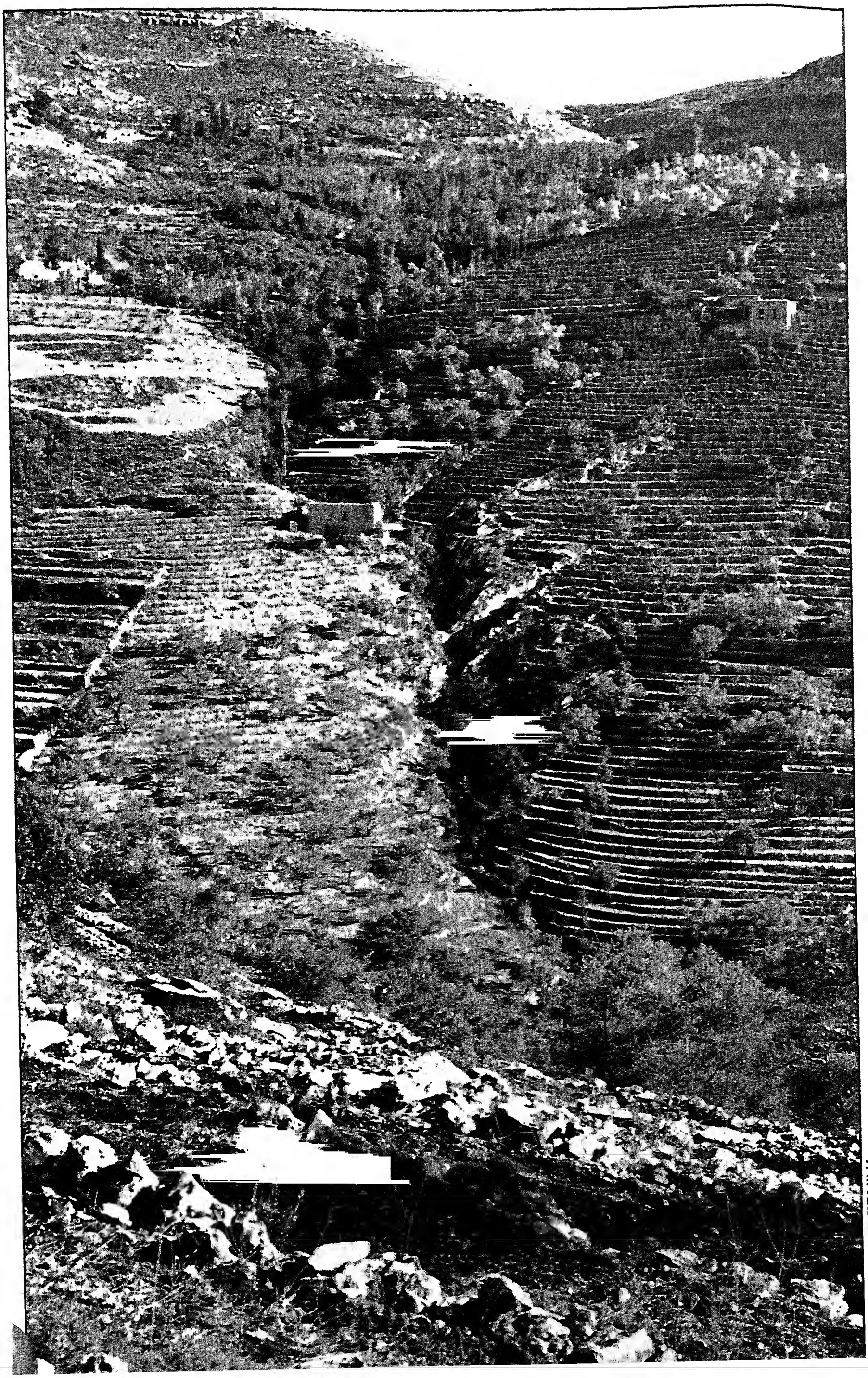

W.C. LOWDERMILK

A World That's Fed Better Than Ever Before

By Wayne D. Rasmussen

"What is the world coming to?" The answer, if we are talking about the food that every one of us needs every day, is "a better place than ever before." Fewer people in the world die of famine each year, not as many suffer from malnutrition, and more enjoy diversified healthful diets than in any earlier age.

Some of us still cling to the ideal of the "noble savage," close to nature, living by hunting, fishing, and gathering. But in most primitive societies, the available food supported only a limited number of people, often with high infant mortality, short lives, and recurring famine.

The development of agriculture, with planting and harvesting of crops and taming and herding of animals, first took place some 10,000 years ago, probably in what is today's strife-torn Middle East.

We do not know just how this happened. Perhaps farming began when some keen-witted person saw that new plants came up where seeds had fallen to the ground the year before. Perhaps the taming and herding of animals began when youngsters made pets of injured or lost young creatures.

It seems likely that as agriculture spread from the Middle East, farming also developed independently in other parts of the world. The result was that man had a greater control over his food supply than before. Of course the earliest farmers, just as today's, depended upon weather, soil fertility, and other natural forces.

Our farming ancestors, using digging sticks, flint knives, and hoes and axes with blades of stone or shell, accomplished feats that modern man has not yet duplicated. Drawing upon wild stock, they developed all major food plants and domestic animals grown today.

Wheat Domesticated

Wheat and barley were domesticated in the first area of agricultural development, southwestern Asia. Rice and bananas were developed later in southeastern Asia, and sorghum and millets in Africa. Maize, known as corn in America, and potatoes were among several major food crops developed in the New World.

Food animals were first domesticated in Asia. The turkey was domesticated in the New World. Eventually these crops, many others, and animals migrated throughout the world.

As time went by, discovery of metal gave ancient farmers sharper, stronger blades for hoes, plow points, and sickles. But the change to metal took place slowly and in some areas—the Americas, to cite an example—not at all.

The first farmers were surer of food from one year to another than

Evidence of ancient agricultural practices still remain in parts of the Middle East. Terrace systems established in Lebanon about 1100 B.C. were still in use when this photo was taken in 1939.

the hunters and gatherers. Nevertheless, every person in a farm family had to work hard to insure that there was enough to last from one season to the next.

Improvements spread slowly up to the last century and a half. A farmer in Roman times would recognize the tools, crops, and animals found on the farm of a soldier in the American Revolution. But neither the Roman nor the Revolutionary farmer would

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An artist's conception of American Indians cultivating land and planting maize in the late 1500's.

recognize the machines used on today's farms. Many of the crops and some animals have been changed almost beyond recognition.

At the time of the Revolution, 90 American farmers were needed to provide the food and fiber for 100 persons. Today 1 American farmer provides 78 persons with food and fiber.

This change has not come about easily nor by chance. Not all countries and peoples have had the combination of natural resources, research and education, and effective representative government enjoyed by the United States.

Fallowing

Until very recently, as man's history goes, improvements spread slowly throughout virtually all the world. Methods the ancients used survived with modifications in many parts of the world for centuries. For example, fallowing, which is letting some land lie idle each year according to a fixed plan, was used in ancient Greece and Rome, in China from perhaps as early as 2000 B.C., and in Germany and northern Europe until recent times.

Fallowing was the basis for England's two- and three-field systems of medieval times. In these systems, the farm land would be divided into two or three large fields. Under the two-field system, half the land was plowed but not planted, the other half planted to grain. In the three-field system, one field was fallow, one planted to wheat or rye, and one planted to some spring crops such as oats, peas, or beans. Through trial and error it was found that nitrogen fixing legumes such as peas, beans, clover, and alfalfa would improve the soil, even though how it was done was unknown.

Two other farm developments in northern Europe during medieval times also increased productivity. Heavier plows that could turn the soil were invented. Invention of the horse collar permitted effective use of horsepower.

These medieval inventions and fallowing are still being used in some parts of the world. Fallowing gave way to crop rotations in many regions. In the United States, rotations were strongly urged by the agricul-

tural experiment stations and USDA. Since then the emphasis has been on specialized and single crop farming. However, fallowing still survives in some parts of the Great Plains, where it is called summer fallowing or strip farming.

During the 1700's, improved breeds of livestock were being developed in Europe and elsewhere. Draft horses heavier than previously were bred in France and England. Cattle that yielded more meat per animal were bred in several European nations. The famous Merino sheep were developed in Spain. North Africa was the native home of outstanding saddle horses.

Livestock Imports

But improvements spread only slowly. The first importations of improved breeds of English cattle into the new United States did not come until 1783. Large numbers of Merino sheep were imported from France and Spain a few years later. Henry Clay, a Kentucky statesman and a U.S. Senator, imported the first Hereford cattle in 1817. Nevertheless, most American livestock during the first half of the 19th century was of poor quality.

In many parts of the world, especially sparsely populated areas that were invaded by Europeans at the beginning of modern times, more land was available than people to farm it. This was true in what became the United States, Canada, Australia, Argentina, and Brazil. In these nations mechanization has bcome more important than in the more densely settled nations of Europe and in Japan, India, and China.

Even in the less densely settled nations, though, mechanization of production is relatively recent. Shortly after the American Revolution, Thomas Jefferson, our third President, designed a moldboard for a plow that would always turn the soil.

A cast-iron plow with interchangeable parts, patented in 1819 by Jethro Wood, was a major contribution. It would not scour in the heavy soils of the prairies, however; the soil clung to the moldboard instead of sliding by and turning over. Two Illinois blacksmiths, John Lane in 1833 and John Deere in 1837, solved the problem by using a smooth steel and polished wrought iron for the shares and moldboards of their plows.

Machine Age

The mechanical reaper was probably the most significant single invention introduced into American farming between 1800 and the Civil War. It replaced much human power at the crucial point in grain production when the work must be completed quickly to save a crop from ruin. The reapers patented by Obed Hussey in 1833 and Cyrus H. McCormick in 1834 marked the transition from the hand to the machine age of farming.

That change was marked by use of horse power instead of hand power—something that would not have been possible without the horse collar of medieval times. The new machinery was adopted slowly until the Civil War. Then the demand for food to feed the troops, grain needs in Europe, high prices, and the shortage of labor because of so many young men being in the armies led farmers to buy the new labor-saving imple-

EDWARD MANNING

Top photo: The mechanical reaper came into use in the 1830's and marked the transition from the hand to the machine age of farming.

Directly above: The introduction of lightweight, gasoline powered tractors was an important turning point in American agriculture.

ments. This shift from hand to horse power was the first American agricultural revolution.

After the Civil War, American farms produced enough food and fiber to satisfy needs of our growing population and to dominate our exports. Agricultural exports in 1865 were 82.6 percent in value of our total exports. This percentage declined slowly but did not fall below 50 percent until 1911. During the 1920's and 1930's, farm exports declined markedly, but have been increasing since then.

World War II saw a tremendous increase in food exports to feed our troops and our allies. The war provided the price incentives for farmers to increase production in every way possible, mainly by adopting the latest advances in agricultural

INTERNATIONAL HARVESTER

technology. Continued postwar demand for food in many parts of the world and price supports of one type or another for farm products kept prices up. The result was great technological advance in much of the world.

In the United States, the revolution included widespread progress in mechanization, with gasoline tractors displacing horses and mules. Commercial production of cotton pickers after the war completed the mechanization of cotton production.

Greater use of lime and fertilizer, widespread use of cover crops and other conservation practices and improved varieties, adoption of hybrid corn, a better balanced feeding of livestock, more effective control of insects and disease, and use of chemicals for such purposes as weed killers and defoliants were part of the second American agricultural revolution.

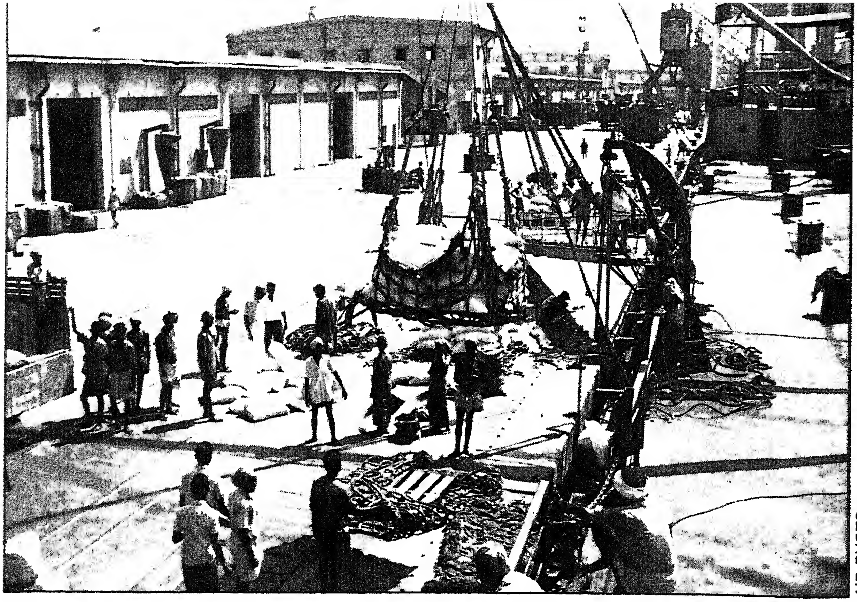
Productivity Jumps

Productivity increased at a rate that outdistanced the rest of the world and, indeed, the rest of the American economy. By the 1950's, the United States was facing keen competition in the export market just as substantially greater productivity was outstripping the commercial demand for our farm products. Yet in part of the world there was hunger and food production was low.

An answer, at least in part, to our surplus problems and unfulfilled food needs in many parts of the world came with passage of the Agricultural Trade Development and Assistance Act (Public Law 480) of 1954. The law authorized the Government to make agreements for sale of farm products for foreign currency, to make shipments for emergency relief and other aid, and to barter Government-owned farm products for needed raw materials.

From 1954 through 1958 exports under Public Law 480 accounted for 27 percent of total farm exports. In 1959, the law was amended to increase dollar sales of surplus farm goods to friendly nations through long-term agreements and extension of credit. During the 1950's, exports of farm products reached higher levels than ever before in American history. At the same time, because some of the foreign currencies were used to aid agricultural improvements in the less developed nations, we were helping many countries meet their own food supply problems.

As agricultural technology improved production around the world, the threat of famine faded even though it has not yet been entirely erased. We think of famine as a severe shortage of food, affecting a wide area and large number of people. One of the earliest recorded famines struck Rome in 436 B.C.,


AID PHOTO

Since 1954 the United States, through Public Law 480, has been able to reduce hunger in many parts of the world through its emergency relief program.

when thousands perished. The entire known world was struck by famines in 879 and 1162. England was struck in 1586.

India suffered three successive famines in the latter half of the 18th century, and eight during the 19th century. Much more recently, in 1967-68, India suffered a famine. However, the death toll was reduced through food shipments from the United States and other nations.

The most devastating famine recorded in history took place in northern China in 1877 when 10 million persons starved. The country has suffered famine many times since.

Famine in Ireland

From 1845 to 1847, Ireland saw disastrous famine resulting from failure of the potato crops. Large numbers of people emigrated, especially to America. By the end of 1848, through emigration and deaths resulting from famine, the population of Ireland decreased by half a million. Many American families today can trace their ancestors to people who left Ireland during the great famine.

Today famines are less likely because of increases in farm productivity, especially in the United States. But more than that is necessary. As the story of Joseph in the Bible tells us, we should build up reserves during good years so we will have food to carry us over the lean. The dry climate of Egypt made it relatively simple for Joseph to store grain for years. It is more difficult for other commodities and in other climates.

Drying and salting food for future use was practiced by primitive man. Both methods are still of importance —nearly every day each of us eats some food that has been dried and some that has been salted or pickled. Primitive man made cheese from milk and wine from grapes

as ways to keep food for the future. Fermentation is also used today. Other means of keeping food have developed rather recently.

France contributed a new method of food preservation, canning. It permitted year-round use of many otherwise perishable foods.

In 1795, when France was at war, the Government offered a prize to the citizen who could devise a way of preserving food for transport on military and naval campaigns. The prize was awarded in 1810 to Nicolas Appert, a Parisian confectioner. He had filled bottles with various foods, sealed the bottles, and cooked them in boiling water.

The technique was used in England with metal cans and then spread over much of the world. Canning offered both commercial packers and homemakers opportunity to preserve perishable seasonable foods for future use.

Refrigeration

Ancient man had recognized that cold kept perishable food from spoilage. Attempts were made with some success to store ice during the winter for summer use at different times and places. During the 1800's, effective storage houses were constructed in the northern United States to keep ice for later use, while iceboxes or refrigerators were developed for home use.

Varied types of food became more readily available throughout the United States and the world with the invention and construction of railroads and steamboats. In the 1860's, refrigerated railroad cars were used to transfer butter, meat, fruits, and vegetables from one section of the Nation to another. The use of refrigeration on steamships, beginning in the 1870's, made Australian, Argentine, Canadian, and U.S. meats available on European markets.

Subsequently, mechanical refrigeration replaced natural ice on railroads and steamships and, indeed, in homes in the more technolgically advanced nations. This meant new markets for frozen foods, first offered commercially in the 1920's. After World War II, frozen food experienced a sharp rise in popularity in the United States.

Production of higher quality food by farmers, effective transportation and storage, efficient processing, and the rise of supermarkets enable most Americans to enjoy a wide variety of high quality, nutritious food throughout the year. Some of these same forces have helped end the threat of widespread, devastating famine in most parts of the world. The storage of large stocks of food, particularly grain, in the United States and some other nations is at least some insurance against major natural disasters anywhere in the world.

American farmers have shown they can provide our Nation with the high quality food it needs at reasonable prices and, at the same time, provide an additional supply for world markets and disaster relief. Meanwhile, we have encouraged farmers in other nations to adopt the agricultural technology best suited to their particular situations so that every nation, like the United States, will become free from hunger.

Wayne D. Rasmussen is Chief, Agricultural History Branch, Economics Research Service.

On the Horizon for Our Food and the World's

By Pat O'Brien and Lorna Aldrich

The 1980's will be a decade of critical adjustments in world and U.S. agriculture. Foreign demand for food and agricultural products is likely to grow at a record or near-record pace. Yet production growth abroad is likely to slow because of limits on the resources available to commit to agricultural production, and limits on opportunities to expand yields. The world's dependence on the United States for agricultural supplies is likely to increase significantly.

This outlook implies that many trends of the last three decades will be gradually reversed—in particular, the tendency for inflation-adjusted prices for agricultural products to decline and for large commodity surpluses to accumulate over time.

Over the 1970's, foreign demand for our farm products grew rapidly to account for 1 of every 3.5 acres planted and 30 percent of all products marketed in the United States. This compares with less than 1 of every 5 acres and 14 percent of marketings in the late 1960's, and less than 1 of every 5.5 acres and 10 percent of marketings in the late 1950's.

During the 1970's, foreign use of U.S. agricultural goods grew almost 9 percent a year, while domestic use expanded only 1.5 percent annually and our agricultural output grew 2.8 percent annually. By 1985, the world may depend on the United States for 15 percent of its agricultural supplies, compared with 2 percent in the early 1950's and 11 percent in the late 1970's. To accommodate this increase, U.S. farm exports would ha to expand 6 to 8 percent a year.

Between the early 1950's and th early 1970's, growth in world food production was generally strong a steady, although unevenly distributed among the many countries o the world. During the same time, food consumption expanded sharp even after adjusting for populatio growth.

By the early 1970's, world per capita food intake had increased t 108 percent of the minimum cited the United Nations Food and Agriculture Organization (FAO) as necessary "...to allow normal acti and good health in adults and to permit children to reach their pot tial body weight in the absence of disease." The level had been abou 104 percent a decade earlier and slightly below 100 in the early 195

Food Trade Zooms

Paralleling this overall improvem in the world food situation, howev was increased dependence on trad In these two decades, the world's trade in food—supplied to an incre ingly large extent by a few export such as the United States—expan roughly twice as fast as productio and consumption. This unprecedented growth in trade reduced fc

In the 1970's one of every 3½ acres planted by American farmers went to foreign markets. This export demand is likely to continue growing in the 1980's.

BOB BJORK

self-sufficiency in the rest of the world (measured as a share of foreign food consumption) from 98 to 89 percent.

The middle and late 1970's stand out in sharp contrast to the previous 20 years. Over the 1970's, year-to-year fluctuations in production and consumption widened considerably and resulted in a marked increase in trade—with the United States supplying a disproportionately large share of the increase.

Of the eight largest percentage year-to-year fluctuations in world food production and disappearance since World War II, five occurred between 1972 and 1979. Unlike the first 25 years of the postwar period, inflation-adjusted prices fluctuated widely and hit an alltime high and postwar low within the span of 5 years.

By the end of the 1970's, food exporters, including the United States, had committed their best land to production to meet expanding demand. The concerns of farm and food policy shifted more slowly. But by the late 1970's, policymakers began to focus on the problem of tight supplies and rising food prices as well as on more conventional concerns of farm returns and excess capacity.

Over most of the last 3 decades, record-breaking population growth, increased affluence, and declining inflation-adjusted prices combined to expand foreign use of agricultural products at a 2.9 percent annual rate, more than double the rate during the first half of the century. Foreign population increased 75 percent in the last 3 decades and accounted for about half of this increase in demand.

Besides population growth, economic conditions in most affluent and some lower income countries were favorable enough to raise inflation-adjusted per capita incomes by 3 percent a year. These income gains in turn encouraged expansion in per capita use of food and agricultural products 1 percent or more annually. In addition, increased affluence in the wealthiest developed countries shifted food purchases toward livestock products and the grain oilmeal feeds used in their production.

Forecasters studying the early 1980's conclude that, despite slower population and economic growth, use of agricultural products abroad is likely to expand 2.5 to 2.7 percent annually. Such increases imply that the volume of farm products used in the 1980's would be nearly one and a half times the volume increases of the 1970's.

Outlook Less Favorable

While their specific forecasts vary, economists agree that the outlook for the next 5 years is less favorable than during most of the 1960's and 1970's. In fact, the next few years are likely to be marked by sharply slower world economic growth and serious, persistent problems of inflation and unemployment.

Recovery starting in late 1981 will probably be more prolonged than in past economic cycles, and growth rates from 1983 through 1985 are not expected to bounce back to the highs following earlier recoveries.

Poorer economic prospects will tend to dampen growth in demand for agricultural products and further weaken the competitive position of many industrialized countries in

large-scale production of food and fiber. Several factors suggest the effect on food demand will be small. Incomes in many developed countries are high enough to weaken the link between economic performance and agricultural demand.

In the lower income developed countries, where higher income will translate more directly into increased purchases, growth prospects are bullish enough—particularly toward the mid-1980's—to accelerate the shift toward more livestock consumption. The shift will, in turn, generate sharply stronger growth in demand for feedstuffs.

Hence, on balance, poorer economic prospects for the developed countries will cut growth in agricultural output more than they cut growth in food demand. Consequently developed countries will import more farm products.

Most developing countries that import oil face a pronounced slowdown in economic growth accompanied by higher inflation and unemployment. Hardest hit will be areas such as South Asia and sub-Saharan Africa where many countries will stagnate economically in the early 1980's. Further worsening the economic outlook for the oil-importing developing countries are deteriorating prospects for trade, private capital flows, and assistance from developed countries.

The outlook for record growth in food, feed, and fiber demand in the oil-exporting and selected high-growth developing countries may more than offset the oil-importing countries' poor prospects. Rising incomes in the 15 to 20 "middle income" developing countries—with a combined population of over 600 million—will boost their food demand and change the mix of products consumed markedly.

Demand for traditional foods such as grains, starches, and pulses will increase in the poorer half of the population in these "middle income" countries. The wealthier half of the countries' populations will generate demand for more livestock products and very rapid growth in demand for grain and oilmeal for livestock feed.

With diets in these "middle income" countries improving in both quantity and quality, demand could expand as rapidly as it did in the affluent developed countries during the 1950's and 1960's.

These widely differing prospects for poorer developing countries, the "middle income" countries, and developed counties will likely keep total demand for food in the 1980's near the rates of and similar to the pattern of the 1960's and 1970's.

Output Pace May Slow

Since World War II, foreign agricultural production has expanded at an annual rate of 2.8 percent, more than twice the pace of the previous 50 years. Leading this expansion were growth in resources allocated to food production, gains in yields, and what appears in retrospect to have been abnormally favorable weather.

During this period, more than a third of the gain in world food production was achieved by expanding the resources committed to food production—particularly land. This expansion was most pronounced in the 1950's and 1960's as new lands were opened abroad, and again in the middle 1970's as the United States returned large acreage reserves to

cultivation. The rest of the postwar production gains resulted from improved farming practices, wider use of inputs such as fertilizer, and adoption of higher yielding plant varieties.

Because of constraints on the world's agricultural resource base and ability to increase yields, the pace of growth in foreign production during the early 1980's is likely to slow to possibly three-quarters of the previous postwar rate. Production gains in the 1980's, due to relatively inexpensive expansion in area, are likely to be significantly smaller than for any other period of the last three decades.

Equally important, much of the new land cultivated in the 1980's likely will be of lower quality, a difference that could intensify year-to-year fluctuations in world output. In the 1960's, less than 20 percent of the land under cultivation was classified as semiarid and rainfall-dependent. By 1985, as much as 30 percent of the world's cultivated land could be semiarid.

Land constraints necessarily mean that future gains in world food production depend on improving yields. For the next five years or so, such growth will depend on speeding up adoption of existing technology and providing farmers with a growing supply of attractively priced inputs. But sustaining, let alone increasing, the present pace of gains in yields could be difficult in the early 1980's

GENE ALEXANDER

Food exporting nations, including the U.S., are presently farming most of their quality land. Future gains in world food production will depend greatly on improving yields and speeding up adoption of existing technology.

as rising energy prices work to raise the price of key inputs and possibly limit their supply.

Few countries could have supported the dramatic gains in food and agricultural consumption in the last three decades through increases in their own production. As a result, world trade in agricultural products increased more than twice as fast as production and consumption since 1950.

U.S. Is Leader

Value of world agricultural trade tripled from 1950 through the early 1970's and has since doubled again. Volume of world trade in grains rose more than 7 percent a year, while the pace for oilseeds and products was more than 9 percent.

The United States has been the single largest source of this expanding agricultural trade. Volume of U.S. grain and oilseed exports doubled in the 1970's alone, while the total value of U.S. farm exports quadrupled.

Based on the foreign supply and demand prospects outlined here, growth in the rest of the world's imports of food, feed, and fiber would have to match or exceed the rate of the 1970's to fill the widening gap between foreign production—growing at 2.1 to 2.4 percent a year, and foreign demand—growing at 2.5 to 2.7 percent.

Many of the same factors implying strong growth in trade in the early 1980's also suggest that foreign demand for U.S. products will vary more widely from year to year. Annual fluctuations in foreign demand for U.S. products grew significantly in the 1970's, and they are likely to continue widening in the 1980's.

Producers abroad will move towa cultivating more marginal lands sub ject to wide weather and yield varia tions. Besides, more countries will move to isolate their domestic markets from changes in world market supply and demand; this in turn leaves an even larger share of worl market instability to be absorbed b the United States.

The increasing role of the United States as the residual world food a feed supplier will tend to translate year-to-year swings in production and consumption—from virtually anywhere in the world—into fluctu tions in foreign demand for U.S. products. These factors could doubl annual swings in foreign demand for U.S. grains and oilseeds to possibly 30 million metric tons.

For the United States to meet th expected growth in export demand and the domestic demand describe below during the 1980's, our agricu tural plant will have to run closer full capacity than over most of the postwar period to date. Significant more of this country's farm and no farm resources will need to be use and used more intensively, to produ agricultural resources. At least for the next five years or so, however, demand and supply here and abro could fluctuate widely enough fron year to year to cause temporary pr lems with surpluses or to accelera the trend toward tight supplies.

U.S. Demand May Rise

Domestic demand for food and fee increased 1.7 percent annually ove the last three decades. Less than two-thirds of the growth was caus by population increases. Greater a fluence and abundant supplies of low-priced products raised per cap

consumption 0.4 to 0.5 percent a year, and dramatically shifted demand toward grain-fed livestock products. This growth was particularly impressive given the already high per capita use of most agricultural products common two decades ago.

Forecasters speculating about the early 1980's suggest that population and income-related growth in demand for agricultural products could slow to possibly three-fourths the rate of the last 20 years. However, strong increases in less conventional sources of demand—including demand for agricultural products for use as biomass for energy conversion—could well push growth in total demand to a near record rate of 1.6 to 1.8 percent a year.

After rising 2.0 to 2.5 percent a year in the 1970's, growth in real disposable personal income will likely slow to about 1 percent per year in the first half of the 1980's. As a result, sluggish growth in consumer spending could dampen growth in demand early in the decade. Forecasters agree, however, that the economy could improve significantly in the middle and late 1980's.

Nevertheless, there is underlying concern that recovery from the 1980-82 slowdown will take longer than following past recessions. There is further concern the United States will also face lower economic growth rates, and higher inflation and unemployment rates, in the long term than experienced during the period from World War II to date.

Impact of this economic outlook on demand for agricultural products is likely to be mixed. Several factors will tend to minimize any demand-growth slowdown.

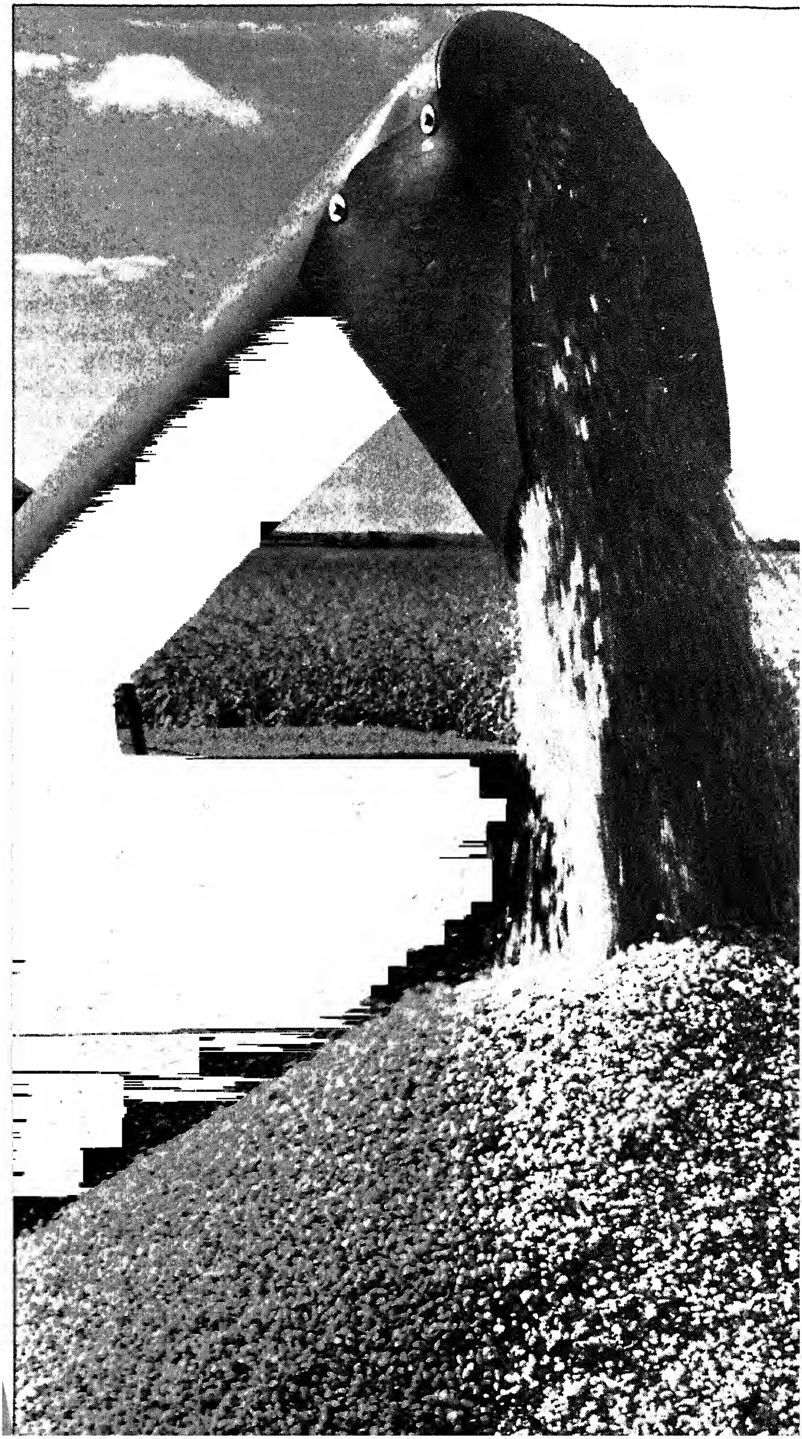
Growth in food consumption is likely to fare well since faster-rising prices for consumer durables and nonfood nondurables will make food a relatively attractive purchase, as Federal and State programs such as unemployment compensation support food purchases among the people most severely affected by the economic slowdown. Hence, on balance, the income-related growth in food demand could drop to 0.3 to 0.4 percent per year in the early 1980's from 0.4 to 0.5 percent in the 1970's. Combined population and income-related growth in demand could drop to 0.9 to 1.1 percent from the 1.2 percent rate of the last decade.

Limited supplies and rising prices for petroleum-based fuels could expand agricultural demand from less conventional sources possibly fast enough to push total demand growth in the 1980's above the rate of the 1960's and 1970's. Chief among these newer sources is demand for fuel and industrial uses of farm products.

Role of Biomass

As inflation-adjusted energy prices increase 2 to 4 percent a year, biomass is likely to become a more attractive feedstock for producing liquid energy. Federal and State subsidy programs will concentrate most of this expanding interest in biomass energy on ethanol production for use in gasohol—with corn as the most widely used feedstock.

While expanding demand for ethanol and, consequently, demand for corn feedstock are likely to push energy-related demand up at record rates, the quantities involved in the early 1980's will be limited by conversion capacity, the economics of alcohol production, and government policy incentives.



If these foreign and domestic demand projections materialize, total demand for U.S. agricultural products could grow around 3 percent a year in the early 1980's, possibly fluctuating 10 percent from year to year. Foreign and domestic demand for U.S. grains and oilseeds could increase from the 370 million ton level of the late 1970's to 430 to 445 million tons by 1985—plus or minus 25 to 30 million tons depending largely on fluctuations in foreign output and demand.

If demand indeed grows at 3 percent a year, U.S. production would have to expand roughly one and a half times faster than the average for the postwar period to date. Production rose about 2 percent a year over the 1950's and 1960's, mainly through yield increases as area was limited by government programs. In the middle and late 1970's, production increases averaged 2.8 percent a year as yields continued to improve and more acreage was brought into production.

Sustaining this growth rate in the 1980's raises serious questions. Given the production growth patterns of the last several decades, the harvested area of major crops would have to expand 10 to 15 million acres by 1985—to more than 130 percent of the average acreage used in the 1960's—to achieve a 3 percent annual increase in output. Will it be possible without committing substantially more renewable and nonrenewable resources to agriculture and without much higher returns to producers?

Cost of agricultural crop production in the U.S. in the 1980's is expected to rise due to limitations of quality land, inputs, and management and the chance of less favorable weather conditions.

Nonland Resources

In addition to expanding cropped area, the demand pressure of the early 1980's will intensify land use, generate changes in cropping patterns, and increase pressure on the forage base. Even if area can be expanded 3 to 4 million acres a year, the yield gains to augment such an increase will require significantly greater use of nonland resources as well.

Raising and sustaining U.S. crop yields at the levels needed to support a 3 percent increase in output would require rises in fertilizer and pesticides use of roughly 4.5 to 5.5 percent a year. The changing mix of inputs needed in the 1980's will also tend to make agriculture depend much more on nonfarm inputs and nonrenewable resources than during most of the earlier postwar period.

Acreage and productivity gains needed to expand output 3 percent a year through the 1980's are certainly within the agricultural sector's physical capacity. The 1977 National Resource Inventory (NRI) identified an agricultural cropland base at about 460 million acres, of which roughly 360 million acres are currently harvested and 100 million are idle cropland or cropland pasture. The NRI identified another 35 million acres as having high cropland potential, and 95 million more of medium potential.

The potential for yield gains through greater use of farm inputs and improved management is also favorable enough to suggest, given the NRI data, a physical capacity to produce well in excess of likely

foreign and domestic demand through the end of the century.

However, protecting the environment while also taking steps to expand production 3 percent a year over the 1980's likely will raise the costs of production in the short term. Equally important, the economics of production will have to be significantly more favorable—both for the near and long term—before the sizable investments necessary to expand capacity can be realized.

The changing mix of resources used in agriculture, and stronger competition for resources from the rest of the economy, will raise the cost of expanding agricultural capacity significantly. Any major expansion in capacity is likely to depend on large injections of nonfarm inputs, labor, and capital—which are in demand from other sectors of the economy.

Further confounding the issue will be the impact on production and producer incentives. During the next few years, growth in agricultural output will likely be hampered by the same basic problems noted for the general economy: higher prices for key inputs and possibly short supplies of them. For at least three crucial inputs—energy, energy-related inputs such as fertilizer, and credit—prices are likely to keep pace with the overall rate of inflation, thus pushing the cost of producing food and feedstuffs up 7 to 9 percent a year.

Agriculture also faces the likelihood that yield gains will slow in the early 1980's and intensify the cost problem. The marked yield gains of the 1977-79 period, due at least partially to unusually favorable weather, tended to disguise much of the period's rise in input costs. Mo normal weather in the early 1980's could reduce crop yields or at least slow yield growth and make cost i creases far more visible. These factors suggest that the early 1980's—contrary to most of the postwar period—could be a time of sharply rising unit costs of production eve without strong pressure to expand output.

A Turning Point?

These prospects all tend to suppor the widespread notion that U.S. ag riculture is reaching a critical long run turning point at which supply becomes less responsive to price in creases because quality land, inpu and management are so limited th additional output is possible only a higher costs. Should this prognosis prove correct, the early 1980's will bring two fundamental changes in U.S. agriculture.

First, on average, annual increas in foreign and domestic demand w begin to outstrip annual gains in U.S. capacity to produce agricultu al products. As a result, inflation-adjusted prices received by farmers given normal weather—should increase; some projections suggest inflation-adjusted price increases of 1 to 3 percent a year, compared with annual declines averaging 1 to 2 percent since World War II.

Moreover, if gains in capacity in the early 1980's due to yield and r source growth are more than offse by losses in capacity due to unit c increases and more stringent environmental constraints, inflation-adjusted prices associated with th output levels needed to balance

foreign and domestic demand could be substantially higher.

Second, the large price-stabilizing stocks and land reserves of the 1950's and 1960's will be conspicuously absent in the early 1980's. This would tend to make American agriculture more manageable, with supply and demand closer to market equilibrium. However, the absence of land and stock reserves would make swings in supply and demand—particularly abroad—an even more critical determinant of the state of U.S. agriculture.

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U.S. Agriculture and World Security

By Daniel E. Shaughnessy

Any examination of the history of agriculture shows its vital importance. But even as the world progresses in other such sophisticated areas as communications and technology, the simple need to grow and distribute food becomes even more critical. In a world which during the past 30 years has seen remarkable progress by many nations in agricultural productivity, the fact remains that the future prospects for meeting world food needs still depend heavily on one nation—the United States.

However, our country's food and agricultural situation is also changing, and attention to food requirements of the United States is an essential prerequisite to actions required of agriculture in the world of the future.

No longer is U.S. agriculture faced with chronic surpluses. No longer is rural America primarily a place of small family farms. No longer is land and water in nearly limitless or abundant supply. And no longer do food and agriculture decisions affect only a small number of farmers and businessmen.

Rather, U.S. agriculture is complex and rapidly changing. It is the Nation's largest employer. The 23 million people employed in agriculture-related jobs make up a fifth of the national labor force. It is an industry that accounts for 20 percent of the Nation's gross national product and whose rate of productivity for the last decade has been greater than nonfarm industries.

The U.S. farmer now produces for a growing domestic and international market (U.S. agricultural exports alone were over $40 billion in 1980); but U.S. farms, which totaled 6.6 million in 1920 now number 2.5 million, with 5 percent of the farmers owning 48 percent of the land. Farmers and those who process farm products use 80 percent of all the water consumed in the country. Farmers apply 20 million pounds of primary fertilizer and a million pounds of pesticides to their fields. In short, U.S. agriculture influences an entire range of activities—from land prices in Iowa to soybean sales in Japan.

Thus, a strong U.S. agricultural system is an essential element of adequate world food supplies. The United States acts as a major supplier to nations with consistent food deficits. It also serves as a reserve supplier to nations that usually are able to provide for their own needs, but occasionally suffer from shortfalls due to bad weather or other transient conditions. This year U.S. exports of wheat will account for 46 percent of world wheat exports; U.S. rice exports will account for 25 percent of all rice exports.

Exports Way Up

During the past decade, the volume of U.S. agricultural exports increased by about two-thirds. In 1978/79, the United States exported 64 percent of its wheat, as well as 26 percent of its

Agriculture is the Nation's largest employer with 23 million people working at agriculture-related jobs, such as food canning.

feed grains, 42 percent of its soybeans, and 47 percent of its rice.

The developing world, which was largely self-sufficient in food production as recently as the 1950's, is now a net importer and is expected to have an annual deficit of 85 million tons of wheat, rice and coarse grains by 1988. In recent years, over half of U.S. wheat exports and nearly three-quarters of exported rice went to the developing world.

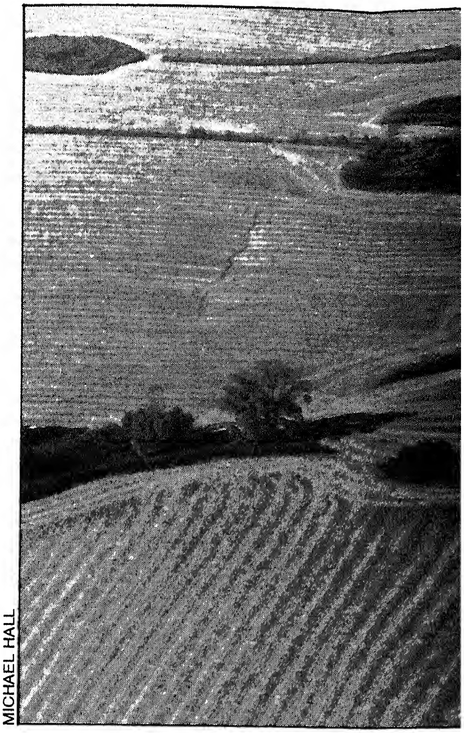
The international aspect of U.S. agriculture has also become a major part of U.S. farm income. Ten years ago, exports provided only 15 percent of market returns for U.S. farmers. Today they provide about 25 percent. For crop farmers, exports bring in almost half of their cash returns. We export 60 percent or more of our country's wheat, rice and soybeans. About a third of our feed grains also are exported.

During the coming decade, rising incomes and growing populations of the developing nations will increase world demand for grain, leading the United States and other grain exporters to increase their grain acreage and production. However, such production increases raise some serious

questions about U.S. resource capabilities.

For example, we continue to lose our best farmland to other uses. Between 1967 and 1975, about 8 million acres of prime farmland were taken from agriculture—6.5 million acres converted to urban and built-up areas and 1.5 million acres to water areas.

Loss of prime farmland forces farmers to grow crops on marginal lands, which usually are more subject to erosion or drought, difficult to cultivate, and less productive. Homes, factories, roads, and other similar uses are absorbing rural land at a rate of approximately 3 million acres a year.



MICHAEL HALL

Land Needs Rise

More cropland will be needed to meet domestic and foreign demand in the future. The 1977 cropland base was 413 million acres. An additional 135 million acres have high or medium potential for conversion to cropland. Of this, 40 million high potential acres can be converted to crops simply by tilling them and applying conservation practices to control soil erosion. Most of the 95 million acres with medium potential have one or more soil limitations that must be considered before conversion to cropland.

Conversion of any of these acres would mean trade-offs, because the 135 million acres of potential cropland are now in other uses. Of these, about 92 million acres are grazing land and 32 million forest land. Converting the land to crops would mean a significant loss in forage and wood-producing areas and, in some cases, wildlife habitat.

For example, converting only 20 percent of this land over the next 50 years for crop production, rather than grazing or forests, would result in using 27 million of the 135 million acres. The accompanying trade-offs would include a major increase in the total value of resources used in production, significant increases in fertilizer and pesticide use, and higher commodity prices. Nevertheless, the cropland potential exists, and with appropriate conservation measures, could be used to increase the U.S. contribution to world food supplies.

But concern about land availability is not the only question asked. Ever-increasing global food needs also affect supplies and prices in the United States, as well as in dozens

Suburban developments, roads, and reservoirs are responsible for the loss of three million acres of farmland each year.

of other countries throughout the world.

However, the differences between food availability and costs in the United States compared to many other countries are still vast.

Struggle for Survival

Several hundred million people in the world struggle for daily survival on incomes which cannot provide even the minimum diet required for good health. These millions spend the majority of their incomes on food, usually the cheapest food that will sustain human life. In Bangladesh, for example, 80 percent of the total caloric intake comes from food grains, and in most of the poorest na-

KAREN RUSINSKI

Faced with the need for more cropland, farmers may start carving it out of existing timber and pasture holdings. This costly conversion will diminish the U.S. timber and forage acreage.

Food is still a bargain. The average American family spends less than 17 percent of its budget on food compared with 50 percent in the Soviet Union.

tions, such grains account for well over half of total calories.

The contrast with the developed countries is striking. In the United States, the average family spends less than 17 percent of its budget on food, and many of the foods consumed are among the most expensive sources of nutrition, such as dairy products, meats and fruits. The same family in Japan spends 25 percent of its income on food, and in the Soviet Union about 50 percent.

The small portion of their incomes that the consumers in the developed nations spend on food, and the types of food consumed, combine to provid a substantial margin of security against the effects of agricultural setbacks. If meat prices should increase sharply, for example, consumers can turn to cheaper varieties, such as ground meat or poultry. In the worst circumstances, there migh be an increased reliance on grain-based products, such as breads or pastas.

However, for those who are alread spending the bulk of their incomes o the most basic foods, a shortage can

spell disaster. In the recent past, world production shortfalls of less than 10 percent have been linked to price increases for wheat and rice of 200 percent or more. Modest shortages, which may raise the cost of bread in the United States by a cent or two a loaf, can result in severe shortages in Bangladesh, or Mali, or Guyana.

Food and Flash Points

This growing interdependence of countries, linked to one another by the complexities of producing, selling, shipping and distributing food, imposes major responsibilities on their leaders and policymakers. A lack of food is among the most destabilizing forces in the world today. Widespread hunger and poverty breed a despair which makes any risk seem worth taking if it promises some hope for a better future.

As a result, it is certainly more than coincidental that hungry nations turn up so often on the lists of the world's political flash points. In short, it must be understood that peace, security, and international economic stability are all factors related to the most basic human need—the acquisition and consumption of food.

For economic resiliency—especially food security—is the cornerstone of effective national strength and world leadership. Americans today are more aware of this hard truth than five or ten years ago, when few recognized the degree to which the United States and other industrialized countries had become dependent upon imports—in our case, imports of oil.

Now, however, the interdependence of nations and the issues that divide them take on far greater meaning and it may well be that U.S. action on its food and agriculture policies are among the most important and viable leadership opportunities facing our country. In this regard, the United States cannot help but be a leading contributor to global economic policy since the role of food and agriculture in national strategic planning, including the assessment of future economic relationships, is critical.

Leadership Role

The United States today has an opportunity—as well as an obligation—to lead the world toward a secure food policy. But we must begin with our own policies and laws. The preeminent part played by this Nation in food production and trade is closely linked to the general state of the world's economy. The inevitability of the worldwide importance of U.S. food policy and legislation—whether domestic or international—becomes more critical each year.

Simply put, the nation that is the world's leader in food production and trade must be the leader in efforts to relate food and agriculture to economic strength and international security. Access to food is a critical part of global security. Policies, strategies and laws affecting food are as much international in their impact as domestic; and the United States has a special place in world food and agricultural matters.

The situation facing the 1980's has not occurred overnight. Energy price increases and the world drought that occurred in the 1972/73 production year, emphasized particularly by se-

vere food shortages in the Sahel region of Africa, were compounded by major purchases of North American grain by the Soviet Union. These events reinforced the need for stability in economic growth and food supply, and demonstrated the growing importance of political involvement in such activities.

Over the next several years, prospects for food supply and equitable distribution of food are fair at best. The 1980's portend a period of uncertainty in supply and demand for basic foods, at least for the first five years of the decade. The price of food will continue to rise and supplies will be tight. As a result, clear U.S. leadership on food policy matters will be essential.

Short vs. Long Term

In recent years, the development of U.S. food policy and related economic activities has been characterized more by reaction than anticipation. Such major U.S. food policy developments as the 1980 Soviet grain embargo, the trend toward bilateral trade arrangements, the use of food aid and economic foreign assistance funds to remedy political situations, and on-again, off-again policy of food reserves, are examples of the development of policy by reacting to specific circumstances, rather than through careful or logical planning.

This form of food and agriculture policy development tends to maximize consideration of short-term gains, usually expressed in domestic terms, and minimize longer term effects—which are often of a global nature.

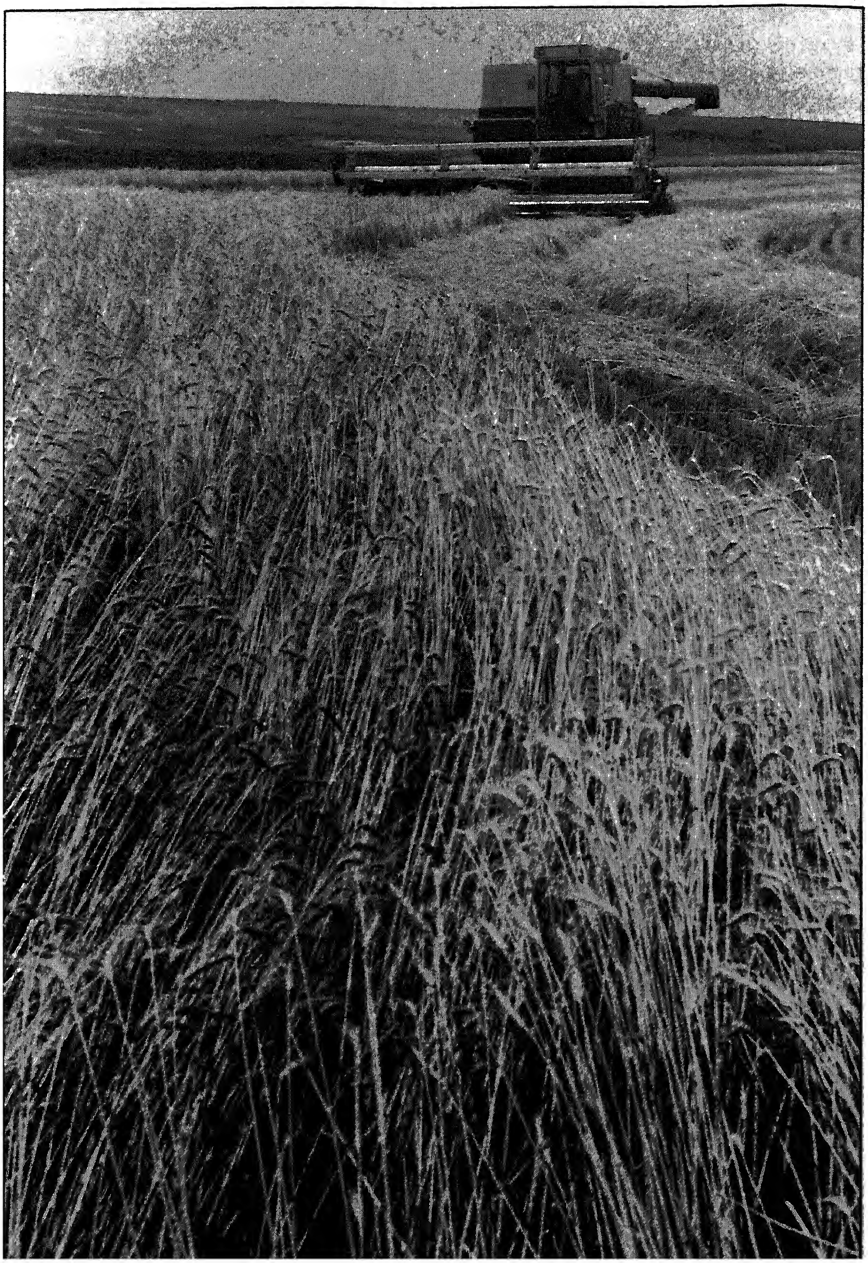
But the United States cannot feed the world alone and we know that we cannot completely transfer our culture and practices to those in need. However, it may well be that frank attention to our own self-interests, together with a policy of assisting others to be viable economic partners, may be the guide to the leadership role the United States can and must assume.

Components of this leadership are a perception of security in a different light beyond that of armed prowess, a recognition of the need for real economic stability, and enlightened U.S. trade and agriculture policies. For the United States, assuring resolution of the problem of food supply throughout the world may well be the key to solving other related issues of economic stability and national and international security.

To do this, the United States must recognize that its food and agricultural policies are no longer its own and that the enormous U.S. export potential in agricultural products is of major significance in this regard. As a result, it will be necessary to apply international criteria to major decisions affecting American farm policy and agricultural production. This will be particularly important with regard to trade in agricultural products, for trade is aid—within reasonable limits—and reinforcing that concept in U.S. agriculture policies will be of benefit both to American farmers and consumers, as well as those throughout the world requiring continuing and reliable supplies of U.S. food.

Daniel E. Shaughnessy is Deputy Assistant Administrator, Export Credits, Foreign Agricultural Service.

Section Three
Food Production



Farm Productivity, Key to Our Level of Living

By Lloyd D. Teigen and B.R. Eddleman

The key to a rising standard (and level) of living for the United States is increasing productivity and expanding production capacity.

Agricultural productivity and production capacity have been tested by a number of events in the seventies. From 1970 to 1979, grain exports increased 170 percent, energy prices rose 160 percent, irrigated acreage went up 60 percent, total acreage planted increased 20 percent, food prices relative to consumer buying power leveled off following a 25-year period of decline (without adjusting for inflation, they doubled), and lower productivity in the nonfarm economy slowed the growth of real income per worker and per capita.

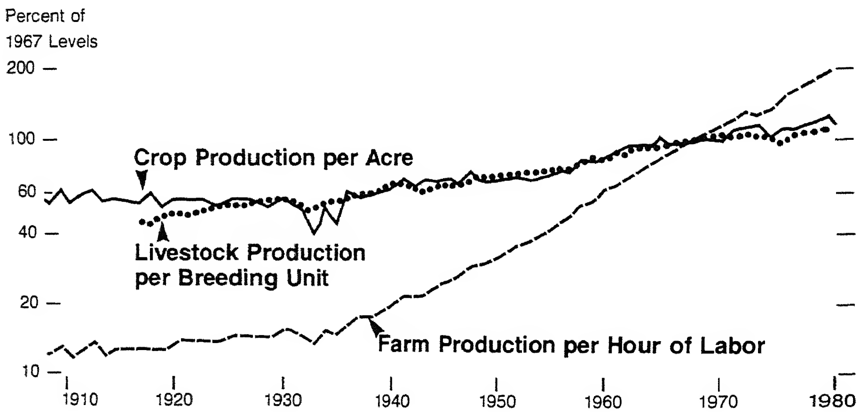
If exports of farm commodities continue to rise, and if irrigation water and energy supplies become tight, and if production costs continue upward, the coming years pose some important questions:

- Is farm productivity leveling off?
- Is the U.S. agricultural production capacity being reached?
- Will the natural resource base maintain that capacity for future generations?
- What breakthroughs of technology and organization of production promise to improve production capacity?
- The bottom line—will the real price of food (adjusted for inflation) resume its decline, or will it rise in the future?

Productivity gains in agriculture affect the real price of food, farmers' income, and the quality of life. They foster economic growth and help satisfy the food requirements of a hungry world.

In this chapter, real prices are de-

Single-factor Productivity Measures



fined in terms of the work required to buy a specific commodity; in other words, consumer prices relative to income.

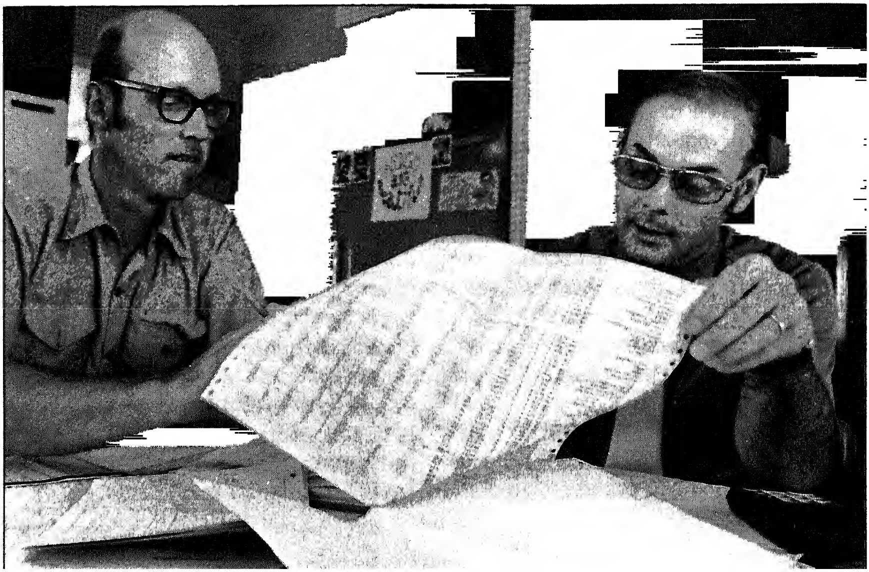
From 1947 to 1972 (the period from the ending of World War II price controls to the beginning of the Nixon Council on Wage and Price Stability), the consumer price index for food relative to the after-tax personal income per member of the labor force declined more than 2.5 percent per year, with annual decreases of more than 3.0 percent in the early sixties.

However, the story in the seventies was different—from 1974 on, most real food prices remained near 1967 levels and only poultry and egg prices are less than 1972 levels. To buy a market basket of food which required an hour's earnings in 1967 would have required 94 minutes in 1950, but only 55 minutes in 1972. The 1980 time cost of that food is 61 minutes.

Production capacity and productivity in animal agriculture influence real food prices in two ways. Livestock production directly affects the price of meats at retail, and increased productivity in the livestock sector lowers the cost of meat throughout the marketing chain, ultimately reducing the final consumer price. Production capacity and productivity in the crop sector combat food price increases two other ways: directly preventing excessive crop price increases when major shifts in demand occur, and indirectly by helping to moderate the real production costs in the livestock industry, keeping retail meat prices under control.

Producer Gains

Producers in the United States



have gained from the productivity increase, although the process was less direct. The increased productivity which lowered real consumer prices lowered farm prices, but it also increased total farm output and output per farm. Besides, the farmer benefits when productivity gains in the industries supplying inputs to him are passed on as lower input costs.

Net farm income per farm has doubled in real terms over the last 25 years despite lower real prices of farm commodities as a result of productivity gains. Had energy and other farm input prices not soared due to the oil embargo and the nonfarm productivity slowdown, farmer income would have grown more. In addition, the farmer benefited from the reduced drudgery of farm work and by not having to work as long for each unit of output.

Recorded gains in farm labor productivity can largely be explained by agricultural mechanization, increased crop yields per acre and output per animal unit, and relatively favorable employment opportunities in the nonfarm economy. All output-increasing technologies, like corn hybrids and fertilization, also contributed to the increased productivity of labor, as well as land.

Gains in livestock productivity are the result of increased feeding of concentrates. This in turn was made possible by the mechanical handling systems for feed and wastes, the advances in animal disease control that permitted large concentrations of animals in confinement, and the greater ability of the animals to ingest feed.

Crop production per acre has responded to increased use of fertilizer and agricultural chemicals. The hybrid seed varieties enabled the fertilizer to be converted into grain rather than green matter. In some parts of the country, production per acre increased as marginal land was taken out of production. Higher rates of fertilization and other management improvements prevented a sizable yield decrease in the South and East during the acreage expansion of the seventies. Changes in weather conditions and the use of other production inputs account for crop yield variability.

Some Answers

Has farm productivity leveled off? Generally no, but the evidence at hand indicates that farm productivity gains are becoming increasingly costly.

Crop yield increases depend on greater use of agricultural chemicals and fertilizer. Some parts of the country have actually shown yield decreases in response to higher levels of land use. High productivity in the livestock sector depends on ever higher levels of concentrate feeding. Labor productivity will reflect the effects of continuing improvements in machinery efficiency more than trends in overall farm production.

The productivity at each stage between the farm and consumer has shown minimal gains in recent years and this is a major contribution to food cost.

Has the agricultural production capacity been reached? Production capacity depends on the resource base and the productivity of those resources.

Capacity in the livestock industry is governed primarily by the size of the breeding stock and available feed supplies.

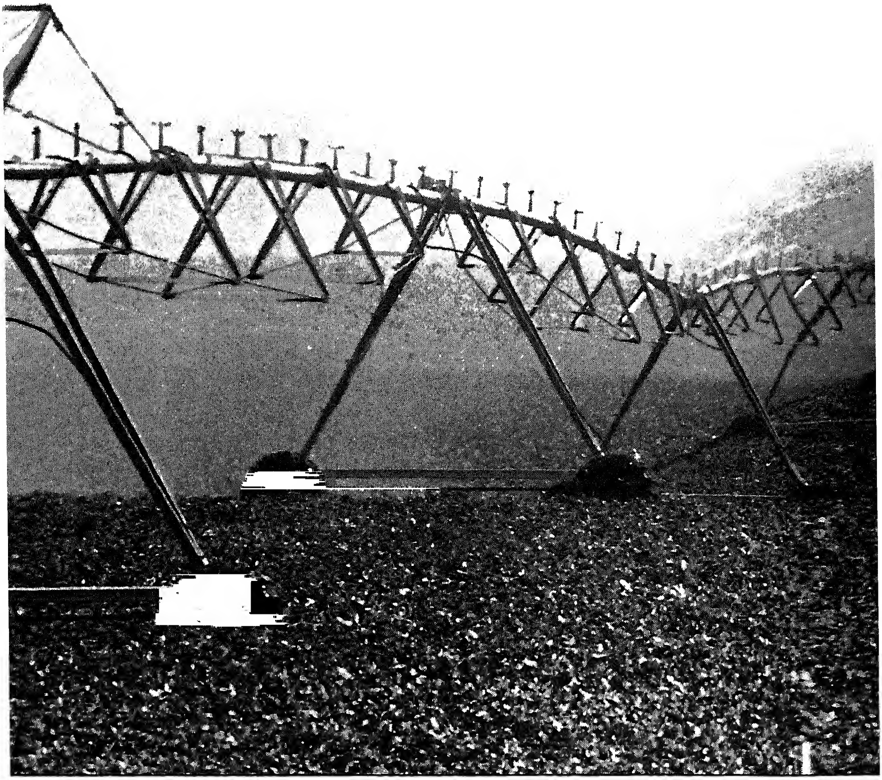
Has the farmer reached the limits in crop yields? Economists say no, but future productivity gains wil become increasingly more costly.

Crop production capacity depends on the genetic potential of plants, the land base, productivity of that land, and available fertilizers, pesticides, and other inputs.

Increased crop productivity has reduced the land required to grow feeds for U.S. livestock, yet land use in 1980 was at historically record levels due to exports. Further expansion must come from land not recently, perhaps never, used for crops. Those lands require much fertilizer and other inputs to approach the productivity of lands currently being used. New technology or increased real farm commodity prices are required to bring these lands into production. The capacity to produce can be expanded, but at a price.

The Resource Base

Will the resource base maintain that production capacity? Production

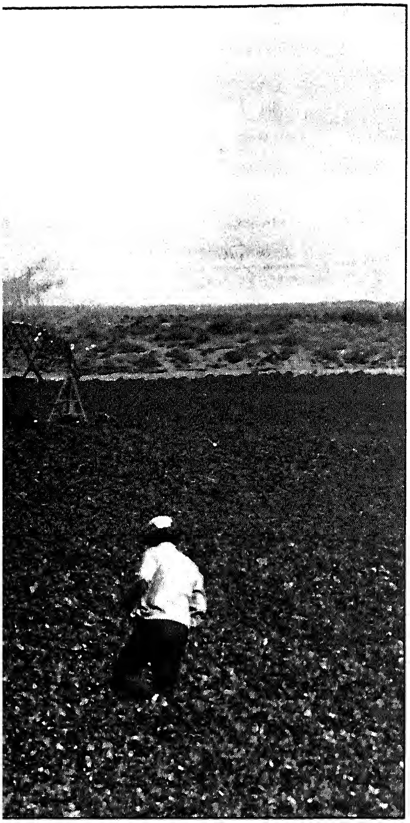


Irrigation increases the productive capacity of the land, but in many areas of the United States — especially the water-short areas in the West — groundwater is being used faster than the underground aquifers are being recharged.

capacity and the resource base are snapshots of a given point in time; they are not fixed forever. The resources committed to, and the technology adopted by, agriculture respond to both price and profit. Whether or not the natural resource base will maintain our productive capacity for the future depends on the development, conservation, and management of those resources.

Soil erosion is a major problem of alarming proportions in Iowa—America's agricultural heartland. But at the same time, land once considered only fit for pasture is now growing corn continuously with less erosion than previously as a result of field consolidation and drainage.

In seven High Plains States, groundwater is being used faster than the Ogallala aquifer is being recharged and Western energy developments compete with irrigated agriculture for limited water supplies. However, sprinkler (and more recently, surge) irrigation systems and improved management practices have greatly increased effi-



:iency of the irrigation water used.

Wise use and management of these :esources dictate that resource de- velopment and improvement invest- nents be made. Unwise use and nanagement will reduce the long :erm capacity to produce. Constraints on the quantity and quality of natural resources are discussed in more detail by later chapters of this section of the book.

Technology Outlook

What is on the technological horizon? Agricultural science is actively pursuing a number of technological and organizational frontiers which could substantially expand production capacity.

Research in genetic engineering has demonstrated the many opportunities nature has provided for plant adaptability. Ability of plant species to resist disease, heat, or drought can be transferred from a gene in one cell of a single plant to entire colonies of other plants through "host cells" other than its "natural" one. Although the methods of moving genes into plant systems have developed slowly, the techniques are beginning to appear and soon will bloom.

Plant tissue culture techniques have reduced the time requirements from laboratory discovery to field use in a number of applications.

Other frontiers of research include improving the efficiency of feed conversion in animals, developing growth regulators which speed up plant growth, improving the efficiency of photosynthesis (the process through which plants turn sunlight into plant sugars) and finding ways to induce plants to obtain their nitrogen nutrients from the air—biological nitrogen fixation.

Many of the breakthroughs will be highly information-intensive, such as integrated pest control strategies. Farm production units will use computerized information systems to analyze such diverse activities as blending animal feed rations, scheduling crop irrigation and pesticide application, and determining both the cropping mix and input use for highest net returns.

In a number of cases, the breakthroughs will combine systems of

existing scientific knowledge, more than relying on new knowledge.

Post-Harvest Potentials

Perhaps the greatest potentials for enhancing productivity to constrain rising consumer food costs are in the post-harvest component of the ag-food system—the protection, preservation, processing and fabricating, and the distribution aspects of the agriculture-food sector.

Among these are solar-based grain drying systems; irradiation as an alternative to canning, freezing and refrigeration in food preservation; and standardized pallets and containers which facilitate warehouse automation. The information from retail computerized checkouts is just beginning to improve ordering-and-inventory control and to lower food prices to consumers.

Later chapters in this section provide a more comprehensive view of the frontiers of agricultural science and the research-education-extension team which generates knowledge and transfers it from the laboratory to production practices.

And what of food prices over the longer term? The real price of food after adjusting for inflation reflects quite imperfectly changes in the production of farm commodities.

Where the assembly, processing, and distribution components of the ag-food system are relatively competitive, farm productivity gains will likely be translated into lower consumer prices, as occurred in fresh fruits and vegetables and livestock commodities.

In those components where a competitive market is lacking, lower real food prices rest on productivity gains in the marketing system (and the nonfarm sector generally) which increase the real incomes of all consu ers more rapidly than the prices of these firms' particular commoditie

There remain important questio about the mix of commodities to be produced among crops and between crops and livestock.

The tradeoffs between domestic and foreign consumers, and the environmental effects and resource co of the options chosen are explored t another chapter in this section.

Our Nation has clearly benefited from gains in the productivity of ou human, plant, animal, and land resources. But in order to continuous increase productivity we must continuously invest in new ideas (research) leading to new resources, machines, and ways of doing thing (capital and technology), and we must extend and communicate thes developments among ourselves.

The institutions, property rights, and management responsibilities must insure that all members of soc ety share the benefits from increasing productivity in order that the new technology be adopted.

The structural organization of production and markets, agricultur resources, technology, research, and extension all interact within the U.S. ag-food system to increase productivity and expand productive capacity and, ultimately, combat real food price inflation.

Lloyd D. Teigen is an economist with the National Economics Division, Economics Research Service, USDA. B.R. Eddleman is Professor of Agricultural Economics, Mississippi State Univesity, Mississippi State.

How Our Team Sent Us to the Food Super Bowl

By Ovid Bay

The "team" used by pioneers was oxen or horses (later mules). That team was vital to the existance of the early settlers as they cleared the land and produced food and fiber which was mostly consumed in the home, with some for barter in local villages. This system of agricultural production required about 95 percent of the population living on the land to produce enough surplus food to permit the other 5 percent of the people to live in the villages as merchants, doctors and lawyers.

As American agriculture expanded and moved West, it stayed "hitched" to this "team" for agricultural production. It was hard work and slow.

During colonial times, farming was recognized as an important source of income as tobacco and cotton became key commodities in international trade. A few leaders such as George Washington and Thomas Jefferson even wrote about and discussed agriculture as a science which could be explored and improved. Washington kept records and experimented with plots and rotations on his farms near Mount Vernon.

But agricultural production did not change much. As fields were exhausted with intensive cropping of tobacco and cotton, new land was cleared and new fields established. New land was more economical than trying to maintain fertility—as long as new land was available.

New Colt in the Pasture

Nothing is quite as exciting as a new colt the first morning you see it trying to get all four of its wobbly legs synchronized and find breakfast at the same time.

The "new colt" that Congress added to the U.S. "agricultural team" in 1862 was named "the Land-Grant Bill" and signed by President Lincoln. This bill endowed States with a total of 11 million acres of public land they could use to establish Land-Grant colleges of agriculture, engineering and home economics.

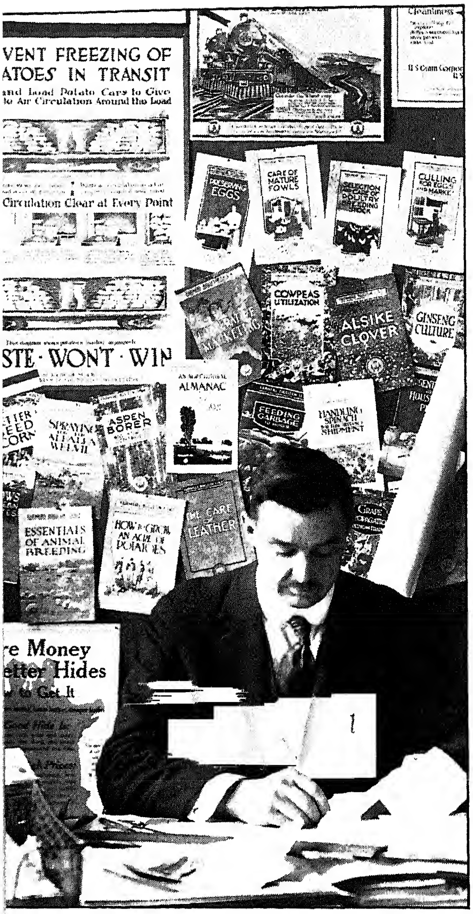
This was the seed money which started a system of basic and applied research for agriculture. It started on wobbly legs but developed into an educational-agricultural-productive system that has never been matched in any other country.

A fortuitous event happened in 1875—both Connecticut and California established an agricultural experiment station!

Stimulated by the demand for the development of research at the Land-Grant colleges, Congress passed the Hatch Act in 1887, appropriating $15,000 to each State for an agricultural experiment station.

The Land-Grant Act of 1890 recognized the part that the 16 predominantly Black institutions and Tuskegee Institute could provide in reaching and teaching additional clientele in the home and on the farm.

Agricultural research was progressing in the laboratory and in experimental plots, but part of the team was missing: How do you get



In the early days, extension service writers and editors quickly moved research information to farm families and agri-businesses through publications and posters.

the research results from the test tube and research bench regularly and quickly applied to the fields and feedlots of farmers and ranchers? Both researchers and farmers saw the need.

Demonstration Trains

From 1904 to 1911, railroad "demonstration trains" carried speakers from the Land-Grant colleges—mostly in the Midwest—discussion selection of seed corn and other subjects at several stops each day. In 1911, 62 trains carried demonstrations and 72 lecturers more than 35,000 miles and reached almost a million people!

What is the best way to get research results from the lab to the farmer?

An uncommonly successful agricultural teacher from New York and Iowa with the unlikely name of Seaman A. Knapp, who obviously preferred the soil to the sea, took the idea of a "demonstration on the train" to a "demonstration on the farm" in Texas. The idea was to show farmers in the area of the Walter C. Porter farm near Terrell, Texas, how following the directions of the U.S. Department of Agriculture (USDA) could help combat boll weevil damage to their cotton yields.

The idea worked. Neighboring farmers watched Porter make $700 more on the field following his use of the new practices, and switched to the same practices the next year (1904).

The seed for "county agents" and "extension of research results" was germinating all over the Nation and caused Knapp to make the famous and wise observation: *What a man hears, he may doubt, what he sees he may possibly doubt; but what he does, he cannot doubt.*

Private and local people (and tax support) recognized the value of Extension's early goal of "helping people to help themselves." This funding plus limited USDA funds gave Knapp the opportunity to start a network of USDA agents in several States in 1906 and 1907.

early methods of reaching farmers with the latest research information was
·m club meetings, usually held at the country schoolhouse.

ion was real and growing! rn Clubs were showing par- value of selecting superior l Canning Clubs introduced l food processing and nutri- formation. But these ers of the Extension Service to come felt the need to ze" their progeny to provide upport and recognition from nding subject matter de- ts at the Land-Grant col- l universities.

ll that accomplished this made the Extension Service educational arm of USDA Smith-Lever Bill signed by t Woodrow Wilson on 914.

gram responsibilities have adened and strengthened by ents to the original act and of other legislation, such as the Agricultural Marketing Act of 1946.

The Cooperative Extension Service now operates in the 50 States, the District of Columbia, Puerto Rico, the Virgin Islands and Guam. Recent legislation will bring American Samoa and Micronesia under the Smith-Lever Act.

13,000 Agents

Today, the results of agricultural research by USDA and university scientists flow from basic research in the test tube and lab to applied testing in field plots to the Extension specialists at the State Land-Grant universities and institutions to the County Extension Agents.

These 13,000 area and county agents serving all of the 3,150 counties in the Nation disseminate the research results to the farm family

PAUL HYSON

Bill Harryman (left), Christian County, Illinois, is one of 13,000 county agents who disseminate research results through on-farm visits, field demonstrations, and workshops.

through farm demonstrations, workshops and meetings, publications, local newspapers, farm magazines, radio and television as well as constantly by telephone.

One of the great strengths of the Education-Research-Extension Team is the "communications network", which moves detailed information quickly through channels that are reliable and can provide answers the potential user may need to speed up acceptance and adoption of a new technology. Many Extension staff members have joint appointments in research and extension.

Proof that the system is working well and accepted includes:

■ A national evaluation report in 1979 estimated two-thirds of U.S. agricultural producers had direct contact with Extension programs in 1978.

■ A recent Gallup poll showed 17 million persons, or about 10 percent of today's adult population, have participated actively at least once in some aspect of Extension home economics and nutrition programs.

■ The adoption by American farmers of hybrid corn and sorghum, short-strawed wheat, performance testing of livestock, integrated pest management, herbicides, fungicides, improved varieties, and new computer farm management technology — which have increased their yields and profits.

The Professional Farmer

President Lincoln's goal was to make

higher education available to youth who could not attend the Ivy League universities in the East. He could not have foreseen how successfully the Land-Grant universities have accomplished his dream. The professional farmer with a college degree—or more—is becoming as common as the professional in the city.

Here's what the "Education-Research-Extension Team" partnership has done to the efficiency and productivity of American agriculture:

- Today, only 2.7 percent of the people in the United States live on farms. They produce enough food and fiber for the consumers in the Nation and to export the production of 1 acre out of 3 being tilled. Over 1 million jobs, not including government workers, are related to the export of U.S. agricultural products.

- In 1980, approximately 65 percent of our wheat production, 42 percent of our soybean production (760 million bushels—compared with 432 million bushels 10 years earlier), and 37 percent of our feed grain production moved into export channels. The wheat we ship abroad will comprise 40 percent of the world trade in wheat.

- Without farm exports, which exceeded agricultural imports by $24 billion in 1980, the U.S. overall trade balance would be that much more in the red.

The success of the Extension adult education program for people in the countryside is due to a Federal-State-County partnership approach with funding 40 percent Federal, 40 percent State and 20 percent county. This educational system is based on the premise that colleges and universities could educate adult people in the rural areas just as effectively as they educate the young people who go to the campus for a degree.

USDA has played a significant role in supporting and funding this concept to bring about an affluent and educated society—especially in upgrading the knowledge farmers and farm families have regarding how to apply new technology to produce food and fiber on American farms and ranches, and to improve the quality of living in rural areas.

From its beginning, the research and extension education function has been the core of the USDA. It has brought to the people on the land improved production, increased efficiency and greater income. It has brought to the American consumer high quality food at the lowest percentage of income of any nation on earth—about 17 percent of the average family's income.

Leaner Meat With Less Grain

Chicken was once considered a special meat for the country preacher as he rotated Sunday dinners with members of his "flock."

"A chicken in every pot" was an economic promise by some politicians. But it took research to discover and extension education to transfer the technology from genetics to the incubator, to improved nutrition, to mechanized feeding, to improved processing and packaging to make poultry products one of the most economical meats for consumers to put in the pot or frying pan today.

Genetically improved "meat type" hogs are making more efficient use of grain and producing pork cuts with a

higher portion of lean meat than pork carcasses of 10 years ago. "Performance testing" of beef cattle is also producing beef cuts with less fat.

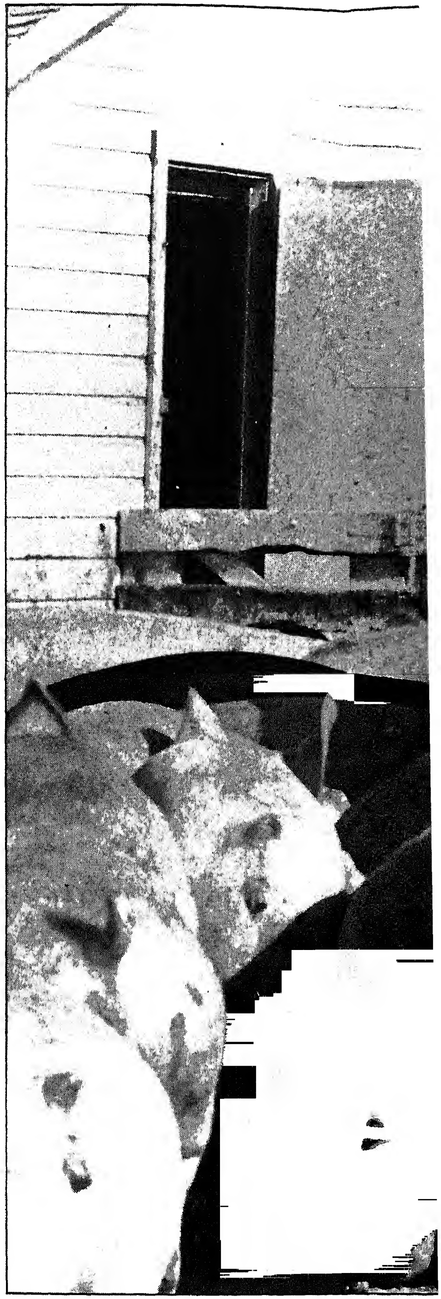
Hens are laying 240 eggs per year compared to 218 eggs 10 years ago. The average dairy cow on Dairy Herd Improvement Association records is producing 14,644 pounds of milk compared to 12,750 pounds a decade ago.

Increased efficiency of production of meat, milk, eggs, vegetables and fruit due to research is reflected in holding down the cost of food and in providing a margin of profit to permit farmers and ranchers to stay in business. Hence the highly efficient American agriculture does show up in the marketplace.

This section of the Yearbook will illustrate with case histories and examples how:

- Techniques such as conservation tillage reduce soil erosion
- Integrated Pest Management controls insects
- Scheduling irrigation conserves water
- Genetic progress will increase livestock production

Ovid Bay is Acting Director of Information, Extension Service.


TOM DeFEO

Livestock farmers take advantage of USDA research and extension education programs in improving meat production. Today's "meat type" hog puts on more lean meat while consuming less grain.

Ways That We'll Continue to Be Well Fed

Coordinated by A.A. Hanson

No one factor determines the success of crop production. Selection of the best adapted plant variety, the best plant population, the best soil fertility program and the best harvesting and storage practice will not guarantee success if weeds and other plant pests are not controlled, or if the crop is damaged by unfavorable weather conditions.

Crop production is influenced not only by advances in plant breeding, pest control and soil and water management but also by the emergence of new plant pests, new races or strains of existing pathogens (disease producing organisms), changes in water supply and water quality, and factors that influence the supply and availability of fertilizer or other essential components of a total crop production system.

Research has been responsible for changing the face of crop production. We can refer to the major research accomplishments that contributed to the advent of hybrid varieties, the introduction of chemical weed control, the development of innovative tillage practices and advances in agricultural machinery, to reinforce the validity of this statement.

However, within the broad framework of modern agriculture, the basic components of production are improved in comparatively small steps. Crop varieties are improved by adding plant resistance to a greater array of insect pests and diseases, and breeding for improved quality and improved adaptation to specific environments. This is true for all research, and hence it is only with time that the full impact of much ongoing research is realized in the improvement of average crop yields and improved stability in crop production systems.

Thus, the average annual increase in yield of soybeans has been about one-quarter of a bushel per year for the past 60 years. During this period, the yield of soybeans on individual farms has increased dramatically following adoption of superior crop production practices.

Starts With Soil

Crop production efficiency starts with our soil resources and the crop germplasm that is available to public and private plant breeders who are engaged in improving the yield and quality of our crops.

Effectiveness of the total system depends on adequate seed supplies of superior varieties, seed that is true to variety and high in purity and germination, use of appropriate soil and water conservation and tillage practices, sound pest control programs, and the correct timing of the many operations involved in production — planting, pest control, irrigation and harvesting.

The system is supported by research and educational programs conducted by public agencies and private companies, by publicly supported Extension agents and private

farm advisors, and by crop consultants who specialize in all phases of crop and soil management.

This chapter includes examples of advances in crop production that have had and will continue to have a significant effect on U.S. agriculture. Among them are research developments in conservation tillage, multiple cropping, efficiency of fertilizer and water use, building improved populations of crop plants, breeding asexual plants (plants independent of sexual processes), plant propagation technology, combating plant pests via breeding for durable resistance, biological pest control and integrated pest management, and the role of growth regulators in crop production.

Many major advances in the technology of crop production are not included in the chapter. We recognize this deficiency but trust that the selected examples will serve to illustrate the manner in which research is supporting the country's need to improve methods of crop production.

A.A. Hanson, coordinator of this chapter, is Vice President and Director of Research, W-L Research, Inc., Highland, Md.

Conservation Tillage

Our soils are our greatest national resource. Technology and management practices developed for clean tillage have allowed production of large amounts of food and fiber on these soils. Clean tillage, however, has exposed the soil to rain and wind and has resulted in potential dangerous erosion rates. Erosion has destroyed the productivity of much of our land and has, in only the last 100 years, removed roughly 50 percent of the topsoil from much of the highly productive central U.S. Corn Belt.

Conservation tillage—which includes those farming practices that leave plant material from the previous crop on the soil surface—has the potential to control soil erosion on many soils and to preserve our soil resource indefinitely.

Conservation tillage reduces erosion because the plant material shields the soil surface from high winds and raindrops and prevents loosening and carrying away of soil particles. If soil is not lost, plant nutrients, pesticides, and soil organic matter remain in the field where they are most useful for crop production.

Why then is all our soil that is vulnerable to erosion not being


WHITE

protected by conservation tillage? The answer is that proven technology and management practices for clean-tilled soils do not always work for conservation-tilled soils.

Planters and drills, which work very well in clean-tilled fields, do not generally work well with plant material on the soil surface. Most conventional planters are unable to penetrate plant material to open a seed furrow and to place the seeds in a uniformly favorable environment for germination and emergence. Plant material on the surface insulates and keeps the soil colder in the spring and thus slows plant growth. If the soil is not moldboard-plowed, fertilizers are not mixed very deeply into the soil. Herbicides that land on the plant material are not effective for weed control unless they are washed to the soil by rain or mixed into the soil by tillage. Cultivators that work well in clean-tilled fields may plug with plant material when used in conservation-tillage conditions.

Farmers with a high level of management skill are adjusting their practices to minimize these problems, and are producing yields equal to or exceeding those of their clean-till farm neighbors. In many instances, however, poor management practices or lack of knowledge concerning best management practices for these conditions have resulted in reduced yields.

Agricultural scientists are working to improve productivity of conservation-tillage systems. State Extension personnel can generally indicate the minimum amount of tillage required for optimum production on given soils. Integrated pest management programs exist in various areas and can be of considerable assistance in designing an insect and weed control program for conservation tillage.

The highest-yielding plant varieties for clean-tilled conditions usually are recommended for conservation-tilled fields. Scientists are breeding into these varieties tolerance to cooler soils, which should help to maintain or increase yields of the varieties when planted in cooler conservation-tilled soils.

Some farm equipment manufacturers are producing lines of equipment specifically designed for operation with plant material on the soil surface. These new designs promote better seed placement under these conditions, better plant stands, and better weed control. Certain fertilizer application implements allow subsurface application of liquid or dry fertilizers while maintaining adequate amounts of plant materials on the soil surface. These technological

Maryland farmer plants corn in previous year's soybean stubble by the no-till method of conservation tillage. This practice greatly reduces the threat of soil erosion and saves energy. Field will be sprayed to control annual weeds.

advances are presently enhancing economic returns of the farmers using conservation tillage.

Loss of a nation's most valuable resource is a frightening thought. However, the United States has lost roughly half of its most valuable, yet most taken-for-granted, natural resource—its topsoil.

The United States has the highest crop returns per acre of any nation on earth, largely because of the soil within the U.S. boundaries. Continued large-scale soil loss by erosion could very likely change this enviable position.

Increased emphasis on technological developments for conservation tillage and increased use of conservation tillage techniques by farmers will help to maintain present soil resources and, it is hoped, will maintain or increase productivity.

By Richard M. Cruse, Assistant Professor of Agronomy, Iowa State University, and Donald C. Erbach, Agricultural Engineer, USDA, stationed at Iowa State. Both are at Ames.

Multiple Cropping—Ace in the Hole

Multi-cropping offers much opportunity to provide additonal production from present land resources and truly is an ace in the hole as world food demands stretch land resources.

This system can be described as growing two or more crops in one growing season, utilizing climatic patterns in different geographic areas to increase total production per unit of land. The multi-crop potential may be the most important of today's modern agriculture developments.

Recent introduction of new technology such as the no-tillage system, herbicides and residue management offers an opportunity to increase double cropping. Fuel for producing agricultural products has become expensive and no longer is available in unlimited supply. By using no-tillage, multi-cropping techniques, two to three crops can be planted with the same fuel required for one conventional crop. Fuel for harvest, processing and transportation would be higher than in single crop production owing to increased production and the extra harvest.

Farmers and researchers agree that multi-cropping can add a minimum of 2,000 pounds of grain production per acre of land compared with single crop production normally used in much of the temperate agricultural zones. Besides increased output, the overall cost of production is reduced. Equipment is used more frequently

and labor requirements spread more evenly through the year.

As farmers move to multi-cropping, timing of planting the second and third crops becomes limited along with pressures of harvesting the mature crop. The no-tillage system, by eliminating plowing and land preparation, reduces the time element while retaining soil moisture present, and reducing runoff, soil erosion and evaporation. These items are essential given the intensive cultivation characteristics of a multi-cropping system. Long-term advantages include improving or at least maintaining soil structure under the stress of planting and harvesting two to three crops every year.

Multi-cropping, historically used in southern regions of the U.S., has expanded into the southern and western Corn Belt with the introduction and adoption of new, reduced multi-cropping tillage systems. Several States now grow 500,000 to 1,000,000 acres of double-cropped grains which add from $100 to $200 per acre in increased gross income. Cash flow is more favorable with sales of crops occurring from 2 to 3 times per year compared to 1 time with single crop growers.

The multi-cropping system used in a given locality depends largely on the climate, with special emphasis on length of growing season and rainfall.

In the middle latitudes of the United States the most popular sequence is winter wheat followed by soybeans, in which case the wheat is harvested as early as possible and the soybeans planted immediately after harvest. In the fall, aerial seeding of wheat into standing soybeans can begin the sequence again, giving the wheat a longer time to begin growing before cold weather comes and saving time and labor in the bargain. The northern limit of this sequence is the southern part of the Midwest.

Other systems which fit the same area are wheat or barley followed by corn for silage or small grains for silage followed by corn for grain.

As one moves south the growing season is longer but the water deficit becomes more severe. In Georgia, for example, wheat can be followed by corn for grain, but it generally is less risky to use grain sorghum because of its better performance under drought stress. In subtropical regions of the country there is the possibility of following corn with sorghum—so that two summer crops are grown in one year.

Unfortunately, with all changes certain disadvantages appear. The most notable with multi-cropping is the added management ability required on the producer's part. Producers need to adjust to

the pressure of harvesting one crop and planting another, and to improve their agronomic information on all crops in the multi-cropping system. Mastering the no-tillage methods of growing crops will be a new dimension for most farmers.

Selection of pesticides must be changed for multi-cropping to prevent possible harmful residues being carried over from crop to succeeding crops.

Multi-cropping is not limited to the large grain grower but is equally adaptable to the livestock producer. Livestock farmers use similar crop species for silage to increase total feed and to provide supplementary silage during low forage production periods created by climatic factors.

Whatever the system, multi-cropping demands careful management to save time and water. One method favored is direct seeding of the second crop in the residue of the first without any preparation of the soil.

The "marriage" of no-tillage with multi-cropping has been the key to its success in Kentucky, Virginia, Delaware and other States. At present, for example, essentially all the wheat grown in Kentucky is followed by soybeans and most of the double-cropped soybean acreage is planted in wheat stubble. As herbicides have multiplied, this planting system has begun to move south where its potential is even greater than in the central part of the country.

The effect of multi-cropping on production per acre is striking. For example, with average yields the wheat represents a bonus production of more than 2,000 pounds per acre since soybean yields are not affected very much and costs of planting soybeans are reduced. Increased income, soil conservation and energy saving all favor the multi-cropping system as well. Nor is the system limited to the United States; Brazil and Argentina both have large acreages where multi-cropping is practiced.

As our management skills increase, the acreage devoted to multi-cropping will rise sharply without additional land requirements. Truly, multi-cropping is an "ace in the hole."

By G.W. Thomas, Professor of Agronomy, and S.H. Phillips, Associate Director of Extension, University of Kentucky, Lexington.

Better Use of Fertilizer

Use of fertilizers has made possible the high crop yields which American farmers have achieved and abundant food supplies for consumers. With rising fertilizer costs, agricultural researchers are

Midwest farmer applies ammonia — a popular source of nitrogen ertilizer — to one of his fields. Of all fertilizers, nitrogen has the biggest ffect on crop yields. Researchers are studying ways to make nitrogen ıore efficient.

tudying ways to increase fertilizer use efficiency. They are invesigating how more yield can be obtained with the same amount of ertilizer currently applied rather than using more.

The soil fertility specialist and plant breeder are joining forces to nd those plant varieties which use fertilizer nutrients more effiiently. Some interesting things point to increased efficiency in ertilizer use by plants.

Large amounts of nitrogen fertilizer are dispensed in crop prouction, and it is the fertilizer that generally has the biggest effect n yield. Corn is the crop in the United States which receives large mounts of nitrogen fertilizer. Researchers have found that corn lants with two ears take up more nitrogen per plant and produce ıore grain than plants with only one ear.

Two-eared plants also remove more nitrogen from stalk and aves and transfer it to the grain. That means these plants are ıore efficient in using fertilizer nitrogen than one-eared plants.

Most present commercial corn hybrids have only one ear per ant. However, in the future we can expect that many will be two ıred, thus profiting from their greater nitrogen efficiency.

Phosphorus is another nutrient supplied in large amounts by lding fertilizer. Most plants in a growing season are only able to ke up 10 to 20 percent of the phosphorus applied. Recent studies ıow the amount of phosphorus taken up by a plant is related to

the total length of roots. Development of plants with greater root length is one approach to increasing phosphorus efficiency.

For many years people have known that pine trees have a fungus on their roots—the association called mycorrhizae. This fungus-root association increases greatly the surface area distributed throughout the soil and which is the absorbing surface for uptake of nutrients. Root systems with mycorrhizae are much more efficient in taking up phosphorus.

Crop plants can be inoculated with specific fungi which will result in much greater uptake of phosphorus. Although this is relatively new, it holds considerable promise for improving phosphorus efficiency.

By Eugene J. Kamprath, Professor of Fertilizer Management, North Carolina State University, Raleigh.

Saving Water

Water is the most limiting natural resource for crop production in semiarid agricultural areas. The amount of water required to produce a crop depends on length of the growing season from planting to harvest and on length of the period that a full green, actively growing crop cover exists. When rainfall plus water stored in the soil since the previous harvest do not meet crop needs, crop yields are reduced in proportion to the water deficit.

Irrigation is used to reduce or eliminate this deficit. Irrigation to eliminate all effects of water deficits on crop yields is usually practiced once a system is installed. Full irrigation in many semiarid irrigated areas is depleting ground water supplies, lowering the water table and increasing the pumping lift (the vertical distance water must be lifted from source to point of discharge).

Pumping costs in some areas have increased several times because of energy costs in addition to increased pumping lifts. In pump-irrigated areas, energy-related costs may account for 60 percent of all variable farm production costs, with about half of these for irrigation pumping.

During the past two decades, we've learned a lot about how to manage water to get the greatest crop production from each unit of water used by the crop. We evaluate the production per unit of water with the term "water use efficiency" (WUE). For example,

- Near Amarillo, Texas, long term WUE for dryland grain sorghum averaged 0.45 kg grain/m^3 of water (3.8 pounds of sorghum

per 1,000 gallons), and that for wheat averaged 0.24 kg/m^3 (2.0 pounds of wheat per 1,000 gallons). Well-timed, limited irrigations can increase WUE for grain sorghum to 1.40 kg/m^3 (11.7 lb/1,000 gal) and for wheat to 0.55 kg/m^3 (4.6 lb/1,000 gal).

■ Crop response to limited irrigation is not the same each year because it depends on climate and especially on the amount and distribution of rainfall.

■ When there is a water deficit, crop yield is reduced less if the deficit is distributed throughout the growing season so that plant water stress develops gradually, allowing plants to adapt.

■ Greatest yield increase from limited irrigations occurs when irrigations are applied just before the critical growth stage, which usually coincides with the period of maximum water use.

■ Greatest yield increase per unit of water pumped is obtained when all the water is made available to the crop—that is, runoff is prevented or reused, water is applied uniformly, and all water applied to the soil is held within the root zone.

■ In semiarid areas, soils often are cropped every other year so some of the precipitation received from harvest of one crop until planting of the next can be stored in the soil. The proportion of precipitation stored during this "fallow" period is called the storage efficiency. Storage efficiency can be increased if the soil root zone is dry at harvest and if conservation tillage is used, which decreases runoff, increases infiltration and reduces evaporation by leaving crop residues on the soil surface.

Maintaining crop residues on the surface is very important. For example, the amount of precipitation stored during a fallow period in the central and northern Great Plains was increased from 16 percent with no wheat straw mulch to 34 percent with a straw mulch. Storage increased from 23 percent without mulch to 46 percent with mulch near Amarillo, Texas.

A limited irrigation before planting is only about half as effective in increasing yields as an irrigation after the crop is established, unless the preseason water is required for seed germination and plant emergence.

A new farming system is being developed for the southern Great Plains that combines the best of irrigation and dryland water conservation practices. Ground water is being depleted in this area and pumping costs are increasing. This Limited Irrigation-Dryland (LID) farming system automatically adjusts the proportion of a field that is irrigated depending on rainfall received during the growing season. Runoff from seasonal rainfall is prevented.

The first year, the increase in grain sorghum production ob-

tained per unit of irrigation water pumped with the LID system was double that obtained with conventional furrow irrigation, in which 35 percent of the water applied was lost to runoff and some runoff from rainfall probably occurred.

Other systems also are being developed to produce maximum crop production per unit of water applied. For example, in Texas a linear move sprinkler lateral has been modified to uniformly deliver limited amounts of water directly to the furrows through drop tubes, which avoids evaporation and spray drift losses. Furrow dams are used to retain all applied water and rainfall.

Trickle (drip) irrigation systems enable small amounts of water to be applied at frequent intervals directly to the soil surface or below the surface. Trickle irrigation is now economical mainly for orchard and vine crops that have low plant density and for high-value specialty horticultural crops.

The amount of water used by a crop is similar with all irrigation methods, but high field irrigation efficiencies are easier to obtain with trickle or sprinkler systems. Trickle systems are easily automated, and nitrogen fertilizer applied through the trickle system can increase fertilizer efficiency. Emitter clogging is the main problem encountered with trickle systems.

By Marvin E. Jensen, National Research Program Leader, Agricultural Research Service, (ARS), USDA, Beltsville, Md., and J.T. Musick, Agricultural Engineer, ARS, stationed at Bushland, Tex.

Genetic Safeguards

A major epidemic of corn leaf blight in 1970 focused worldwide attention on the dangers of planting too much acreage of any crop to varieties susceptible to a single disease or insect pest.

That event led to a study by the National Academy of Sciences. The Academy's report, published in 1972, showed that as few as 6 to 10 varieties were used to plant more than half the acreage of each of our major crops. It cautioned plant breeders to develop large numbers of "reserve" varieties and to search out and use diverse breeding material able to counter new disease or insect pests. And it urged government to actively support germplasm banks—collections of breeding material gathered from around the world, carefully evaluated and safely stored for future use by plant breeders.

Response by plant breeders in the nearly 10 years since this report's publication is encouraging. Progress was recently measured by a survey reporting on the status of breeding programs of over 75

JOE LARSON

Technicians check the emitter on the plastic hose in a drip irrigation system set up in a young avocado grove in California. Drip irrigation is a highly efficient way of applying water on orchard and vine crops.

percent of the U.S. breeders of cotton, soybeans, wheat, sorghum and corn.

The survey shows that while farmers still tend to plant a large proportion of their acreage to a relatively small number of superior varieties of each crop, an appreciably smaller percentage of acres was planted to the top six varieties of cotton, soybeans and corn in 1980 than in 1970.

The new survey also documents the increasing rate at which leading varieties are being replaced. This turnover in varieties, called "diversity in time," helps prevent buildup of disease and insect pests specific to a particular variety. For example, most varieties are now planted only 6 to 10 years before being replaced by newer, superior ones.

Further, the breeders who were surveyed believe varietal lifetimes will be shorter in the future because of greatly increased plant breeding activity in the private sector, especially in cotton, soybeans and wheat. (Corn and sorghum breeding have had large contributions from the private sector for many years.)

The survey revealed a second important safeguard against genetic vulnerability: We have a very large number of reserve varieties on hand in each crop.

First-line reserves—fully tested varieties and hybrids now grown on farms—are up to 100 times as numerous as the 5 to 10 leading varieties in each crop. Supplies of these could be rapidly expanded, if needed.

Second-line reserves, with several years of testing but not yet released, usually number in the thousands for each crop. Third- and fourth-line reserves, varieties in the early stages of testing, number in the hundreds of thousands.

Equally important, a strong majority of the breeders in each crop say that breeding materials in their programs are more diverse in genetic background than they were ten years ago. Sources of this increased genetic diversity include elite varieties from other parts of the world, primitive varieties from areas where the crop is most diverse and has undergone the most selection for resistance to numerous disease and insect problems, and weedy relatives of the crop species or even related wild species.

Although this issue was not included in the survey, it should be noted that individual farmers contribute to further genetic diversity by planting several hybrids or varieties with varying genetic backgrounds.

Plant breeders listed a number of activities which could help them further broaden the genetic base of our major crops. Many

items in the U.S. germplasm collections are not described adequately; in order to use them, they must first be grown and evaluated, delaying their use in meeting a new insect, disease or other environmental change. More efforts should also be made to add to the collections before old varieties—irreplaceable sources of genetic diversity—disappear as farmers in developing nations replace them with modern, high yield varieties.

In total, the survey provides a picture of progress. The level of genetic diversity in breeding programs for major crops has been greatly improved in the past ten years. A majority of the breeders surveyed see little chance of another 1970's-like disaster caused by excessive genetic uniformity.

Increased plant breeding, stimulated by legislation that helps companies recover their research investment, promises to further increase the genetic diversity that now exists. Thousands of "reserve" varieties stand ready to quickly meet unforeseen problems.

In addition, the worldwide linkage among plant breeders, increasing cooperation among government and commercial breeders, and new breeding techniques all point to further progress in broadening the genetic base of our major crops.

By Donald N. Duvick, Director, Plant Breeding Division, Pioneer Hi-Bred International, Inc., Des Moines, Iowa.

Cloning Plants Through Seed

Basic research on plant reproduction has led to a new method for breeding certain forage grasses that could make commercial hybrid production possible in several crops.

Nature provided plants of some species with an unusual reproductive system in which seeds are formed by a vegetative (asexual) process called apomixis. Apomictic plants mimic the normal sexual method of pollination and fertilization that takes place in the flower, but the male and female sex cells (sperm and egg) do not unite to form the embryo. Instead, the embryo of the seed develops from a vegetative cell in the ovary of the female and receives no genetic material from the male.

Apomixis provides a system for cloning plants through seed. The offspring are all identical and exact replicas of the maternal parent, like growing plants from buds of a potato but with the convenience of seed propagation.

Scientists recognized that apomixis could provide a unique vegetative method of growing successive generations of hybrid plants

from seed; hybrids that would remain uniform and retain their important characteristics and hybrid vigor in advanced generations. But first it was necessary to find a way to hybridize apomictic plants, because complete apomixis in a species prevents crossing and eliminates the natural variation from which new strains are selected.

A breakthrough became possible when scientists found that most apomictic species have some sexual or partially sexual plants that can be crossed with apomictic plants. Then they discovered that apomixis is genetically controlled and can be transmitted from parent to offspring.

Subsequent research with forage grasses showed that hybridization of sexual and related apomictic plants produced both sexual and apomictic F_1 hybrids (asexually reproduced hybrids) having combined characteristics of the parents. Offspring of the sexual hybrids segregated as expected of sexual hybrids, giving many genetically and morphologically (structurally) different plants, but those from apomictic hybrids were completely uniform and just like the F_1 hybrid parent.

Thus a new approach to breeding, the production of true-breeding F_1 hybrids, was demonstrated. As a result, valuable new F_1 hybrid cultivars of a drought-resistant range grass, buffelgrass, are available for the first time.

Scientists visualize a much wider application for apomictic plant breeding than just forage grasses. In addition to wild and cultivated grasses and many weedy species, this strange method of reproduction occurs in species of citrus, berries, and probably apples and wild beets. A few strains of grain sorghum with low levels of apomixis have been identified and breeders are working to develop completely apomictic plants for breeding purposes.

Apomixis occurs in wild relatives of some important food crops such as corn and wheat. With modern genetic engineering techniques, breeders may soon transfer genes for apomixis to these crops and perfect the apomictic breeding technique. Scientists in the United States and the Soviet Union are already engaged in research designed to transfer apomixis from a wild grassy relative, gammagrass, to corn.

Among other interesting possibilities, scientists envision development of world centers where great numbers of apomictic hybrids of a crop can be produced for testing throughout the world. Developing countries could draw a wide assortment of hybrids from this world plant bank and test and identify the strains best adapted to their conditions, thus avoiding the expense of a major

plant breeding program. Since apomictic hybrids do not change in future generations, the superior ones could be increased and used for commercial production. Farmers could even harvest and plant the seed year after year.

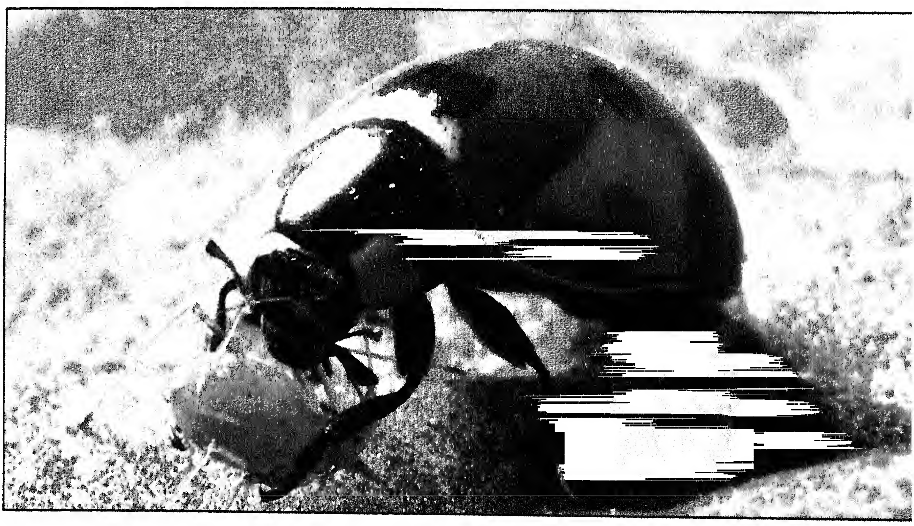
By E.C. Bashaw, Geneticist, Agricultural Research Service, USDA, stationed at College Station, Tex.

Biological Control of Pests

Agricultural pests including insects, plant diseases and nematodes, and weeds are direct competitors with people for food, feed and fiber. Were it not for pest-induced losses, the amount of land now cultivated to crops could be reduced by 50 percent.

Pests compete not only with people but with each other and with non-pest organisms. Every ecological niche is a battleground. Each biological organism attempts to gain an advantage but nature keeps it under control by exerting various checks and balances—a very delicate balance. For example, aphids, an insect pest, begin their activity early in the spring when it's warm enough for them to feed and reproduce but too cold for parasites and predators, their natural enemies or biological control agents (BCA).

In nature, there are many kinds of plants and the actual numbers of food plants for aphids are few and interspaced among non-food plants. However, these food plants are more than ade-



A seven spotted ladybird beetle feeds on a destructive pea aphid. The beetle is a biological control agent introduced to control the aphid.

quate because only a few aphids have survived the winter and because their enemies are still in a resting stage (diapause).

Aphid numbers multiply rapidly as the season progresses. But by now it is warm enough to revive the BCA's from their diapaused state and they begin to parasitize or feed on the aphids to survive and reproduce.

As the season progresses, the BCA's have done their job and the aphid population decreases. As a result, there isn't enough food to maintain a large population of BCA's. Therefore, the population decline of the BCA's follows until their numbers are low enough to allow the aphid population to increase. The cycle repeats itself throughout the year and is nature's way of maintaining a balance among the host plant, the pest and the BCA's. Any factor that affects one of the living systems affects the remaining two.

We upset this balance significantly when we began cultivating crops by concentrating all the food for pests in one place in the absence of non-food plants, thereby reducing the hazards for the pests associated with food search. We further upset the balance by accidentally transporting pests away from their native habitat and leaving behind their natural enemies. Most of the key destructive pests in the United States are of foreign origin.

Scientists have studied and continue to study the pest-host and pest-BCA relationship, ecological factors affecting population density, origin of pests, etc., seeking new BCA's and ways to use them to the advantage of people. Numerous opportunities have been uncovered by scientists but there still are many secrets of nature that need to be discovered.

Scientists found that pests are controlled in nature by mammals, birds, amphibians, mites, insects, nematodes, fungi, bacteria, protozoans, viruses, and rickettsial organisms. However, the use of all these is not practical in agriculture at this time because some cannot be directed against the pest we are trying to control, others can't survive our climatic conditions, still others will not remain in the area one wants to protect, etc.

There are lots of examples of the practical use of biological control agents. Most of the successes have been through foreign exploration, and eventual introduction and distribution in the United States. The majority have been for controlling insects and weeds.

Many kinds of BCA's have been employed against insects. Parasitic wasps have been used successfully in Florida, eliminating the need for extensive pesticide use. A bacterium, *Bacillus thuringiensis,* effectively controls many destructive caterpillars and recently new strains of this bacterium have been discovered that con-

trol mosquitoes and black flies. A virus is registered for use against certain field and forest insect pests. A protozoan specific against grasshoppers provides long term control, and when mixed with low dosages of insecticide and bran, provides an effective grasshopper bait for long- and short-term control.

Weeds are attacked by fish, snails, insects, fungi, viruses, bacteria and even ducks. Most successes in the biological control of weeds have been with insects against such pests as water hyacinths, cacti, and several thistle species. However, fungus has been used experimentally to control northern jointvetch in rice and soybean fields. Another fungus controls strangler vines in Florida citrus orchards; and a third fungus controls water hyacinths in Florida waterways. A rust disease was used successfully to control skeleton weed in Australia and pamakani weed in Hawaii.

Nematodes, viruses, bacteria and parasitic plants (dodder, witchweed), many of which live on specific kinds of plants, could be used in weed control.

Biological control of nematode pests has not advanced as rapidly as with insects and weeds. However, limited research indicates numerous BCA's exist including fungi, bacteria, small soil animals and even nematodes. For example, a bacterium parasitizes the soybean cyst nematode, a fungus reduces populations of root knot nematode of peaches, and another fungus parasitizes cereal cyst nematode.

Biological control of plant pathogens has only recently begun to expand. The presence of many species of bacteria and fungi have been found to limit or reduce population growth of a number of plant pathogens (antagonism). Antagonism has been observed on pathogens attacking the leaf surface and rootzone of crops. For example, soil amendments from areas with little or no effects of a pathogen when introduced to soils with high incidence of disease can reduce the effectiveness of that disease. Addition of specific fungal BCA's have controlled damping-off and take-all diseases of several vegetables, grains and field crops.

More innovative approaches to biological control include protection of corn, pea, bean and sugarbeet seeds from two disease organisms that attack the young seedling by coating seeds with saprophytic molds; incorporation of certain crop residues which intensifies microbial activities to produce decomposition products that affect soil-borne pathogens; stimulation of a host plant to resist a disease organism by introducing a "non-virulent" related species of the disease organism; and manipulation of insect BCA's to remain in a target area and elicit optimum search

patterns for insect pests with use of kairomones, chemicals emitted by hosts or preys which attract BCA's.

One area not mentioned, a form of biological control, is breeding plants resistant to pests. Were it not for resistant varieties of crops, we would not have been able to produce all the food, feed and fiber to meet our needs today.

The future for biological control remains bright because it is a key element in the emerging integrated pest management systems, it is environmentally sound, it does not threaten human health and safety, and it can be utilized economically—thereby increasing productivity.

By Milton T. Ouye, Group Leader, Crops, Program Planning Staff, Science and Education Administration, USDA.

Durable Resistance to Diseases

Use of single resistance genes has been the principal approach to disease control by hereditary means for over 75 years. The ease of incorporation into acceptable plant types and the containment of disease to insignificant levels account for the continued popularity of the so-called "major" resistance genes. Unfortunately, single-gene control of certain explosive pathogens has proven ineffective and disastrous, because "major" gene resistance is effective against certain races of a pathogen and totally ineffective against other races.

Most plants can endure a certain amount of disease without ill-effect; the amount of tolerable disease will vary for different crops and diseases. Thus, it is not essential that disease be *controlled* to essentially zero levels, by use of "major" genes, if it can be *managed* to a level below that of the yield-loss threshold.

There is a kind of disease resistance available that can do precisely that. This resistance usually is conditioned by several so-called "minor" genes which function collectively and additively to affect the rate at which disease develops and, thus, the final amount of disease.

Rate-reducing resistance restricts the number of successful infections, reduces the amount of plant tissue that becomes diseased, curbs the amount of inoculum that is produced for the next cycle of disease increase, and, in general, slows the entire disease process.

An important virtue of rate-reducing resistance is that it retains an acceptable level of effectiveness regardless of genetic changes in a disease organism. Thus, rate-reducing resistance does not exhibit

the "feast or famine" syndrome often associated with "major" genes that are effective only against specific races. The resistance is durable and long-lasting.

The presumed difficulty of incorporating the necessary resistance genes into an acceptable plant type has discouraged many plant breeders from attempting to exploit durable resistance. However, the technology is available now to detect rate-reducing characteristics and to manipulate genes that operate them. The task is not nearly as difficult as was once thought.

The tremendous potential of durable resistance has added a new strategy to man's meager arsenal of schemes to combat the many organisms capable of causing plant diseases. The question is where do we find the genes to breed for durable resistance.

Scientists often turn to wild relatives of cultivated plants in search for usable resistance genes. Many wild plant species and their parasites exist today in harmony and genetic equilibrium. The wild hosts sustain modest levels of disease which does not threaten their reproduction and survival. In fact, wild hosts react much like our cultivated plants that possess durable resistance.

I have theorized for years that wild host species exist today in harmony with their parasites by virtue of the collective action of several genes that restrict the buildup of disease. I propose that the resistance genes were added one at a time and that the early resistance genes functioned as "major" genes that were effective in *controlling* disease until overcome by a new race. Genes that once functioned separately with temporary success now function collectively with durable success.

I now have research evidence that "major" resistance genes when combined in populations of crop plants, are capable of reducing the rate at which various races of a pathogen will damage the crop. "Major" genes that have lost their effectiveness in controlling a pathogen continue to exert some influence on the expression of a disease. Such genes continue to be important in developing pest-resistant crops.

Thus, combinations of "major" genes that are currently effective and those that have lost their effectiveness hold the key to success in our search for superior crop varieties that possess high levels of durable resistance to diseases. Such a non-conventional concept of "major" genes for disease resistance could lead to a new era in plant breeding.

By R.R. Nelson, Evan Pugh Professor, Department of Plant Pathology, The Pennsylvania State University, University Park.

Integrated Pest Management

We need food and we must be able to depend, year after year, upon adequate food and fiber that only stable crop production can supply. Many countries have neither an adequate nor a stable agricultural production system—malnutrition and a host of other health- and social-related problems result. Stable production of agricultural products depends upon many things, but plant protection from losses caused by pests is a very critical one.

Pest numbers are legion and may take many forms—insects, mites, nematodes, weeds, plant diseases, rodents, plus more. Man has always sought means to cope with pest-induced-problems. These operations involve protecting man's health, comfort, esthetic values, and freedom from annoyance, but certainly protecting domestic animals, crops, forests, and other property is one of the most important.

Insect problems are not unique to modern civilization. Graphic accounts of insect attack are found in literature of the ancient Hebrew, Egyptian, and Greek civilizations. The Bible mentions insect problems, of which 11 species can be identified, including the familiar body louse, clothes moth, flea, and desert locust.

Early attempts to cope with pest problems were largely ineffective, at best feeble, and man was forced to share his abode, body and food supply. In relatively recent years, however, advances in our knowledge of pests' habits and life history and a rapidly advancing technology have given man, in our more advanced societies, reasonably effective means of protection.

Concentrated efforts to control a variety of organisms largely began with the development of agriculture, more or less 10,000 years ago, and permanent settlements. Early efforts were poor, some dealing with mysticism, but gradually a few chemicals were discovered, sulfur, for example, with moderate to good effectiveness on certain pests. In the early 1900's, pest control was still grossly inadequate and losses to pests were consistent and even at times catastrophic.

In the mid-1940's, the first synthetic organic pesticides began to appear, beginning with DDT, BHC and 2, 4-D. These, plus those which soon followed, opened a new era in pest control. For the first time entomologists were able to reduce quantity and quality losses to many insect species. In the United States, crop yields increased over 50 percent. Not all of this increase can be attributed to new pesticides, but they are a major factor and added a stability to

Montana ranchers in the 1900's banded together to mix poison bait in an effort to control a grasshopper infestation. In most cases, pest control in those days was ineffective.

agricultural production never before possible.

A major advantage of the new pesticides was their rapid effect and the fact they can bring immense populations of pests under immediate control. Also, they can be used as needed.

Insecticides, more than other pesticides, were applied repeatedly, often with little thought or information on whether the application was really necessary. Gradually problems began to evolve from such heavy dependence upon insecticides. The potential hazards from repeated use cause serious social concerns about effects on human health and the environment.

More immediate concerns at the crop production level involved the rapid selection for insecticide resistance, and the general lack of selectivity between destruction of pest and beneficial species. In combination, these concerns threatened to lessen our capacity to maintain stability in crop production.

Over a period of time, repeated exposure to a pesticide has selected races in an insect population that are sufficiently resistant so a change in control procedure was necessary. Resistance developed to one or more insecticides in over 400 species—most of which are serious, consistent pests. In many, resistance is so widespread and to such a wide variety of chemicals as to threaten

continued successful dependence on this means of control.

Resistance to plant diseases is steadily advancing also, and in a few cases rodents and weeds have developed resistance. In regard to weeds, this is not considered serious, however.

The general lack of selectivity of insecticides between pest and beneficial species created very different problems. Beneficial insects—parasites and predators, along with insect disease, provide a large degree of natural control of many pest species. Removal of such desirable organisms often resulted in secondary pest problems developing, and in primary pest populations quickly rebuilding to damaging levels. Thus, more insecticide was needed and sometimes a treadmill of treatment resulted. This description is vastly simplified, and it did not always occur. It serves to illustrate, however, why plant protection scientists began to look for additional systems of managing pests.

It is obvious to experienced plant protection scientists that chemical pesticides will remain a most valuable tool among plant protection techniques. At this time the farmer has little recourse but to use a pesticide when pest populations reach damaging levels. Other tactics are needed and, in fact, some old and newly developed tactics are available and being used in field practice.

Some of the old tactics include use and protection of naturally occurring biological control agents, regulatory procedures, cultural controls, and pest-resistant and tolerant crops. Some such as crop rotation and physical and mechanical controls have been employed for hundreds of years. Others, such as the use of synthetic sex pheromones (chemical attractants), are relatively new and already playing a role in pest control programs.

Entomologists were soon joined by plant pathologists, nematologists and weed scientists in the search for management systems to best put all existing technology with compatible programs. Integrated pest management (IPM), sometimes called integrated control or simply pest management, was the term given the developing management systems. This is simply a program, recognizing the complex biological nature of agricultural crops, in which all techniques of managing pests are integrated into a systems approach so each control method or tactic used complements the other. Insofar as possible, there is decreased reliance upon non-selective methods of pest population control.

An immense task lies ahead for the plant protection scientist, who must develop a large body of complex data in order to devise better crop and pest management systems. It is expected that computer technology will play a valuable role in developing predictive

models once the data are available.

Some integrated pest management systems are already in use, although few can be considered in final form. Considering the genetic plasticity of plant and pest populations, it is likely that we will never have any in a totally final form. A second task ahead will be to educate farmers to advantages of a developed IPM over current pest control programs. This will involve demonstration—particularly to show economic advantage.

Generally, plant protection personnel agree that to continue existing pest control practices is recklessly extravagant and wasteful and could lead eventually to a decline in our ability to control pests. If this should happen, we most probably will gamble with food production stability. Integrated pest management, even though not perfect, is our best route to stability.

By H.T. Reynolds, Professor of Entomology, University of California, Riverside.

Chemicals Make Plants Behave

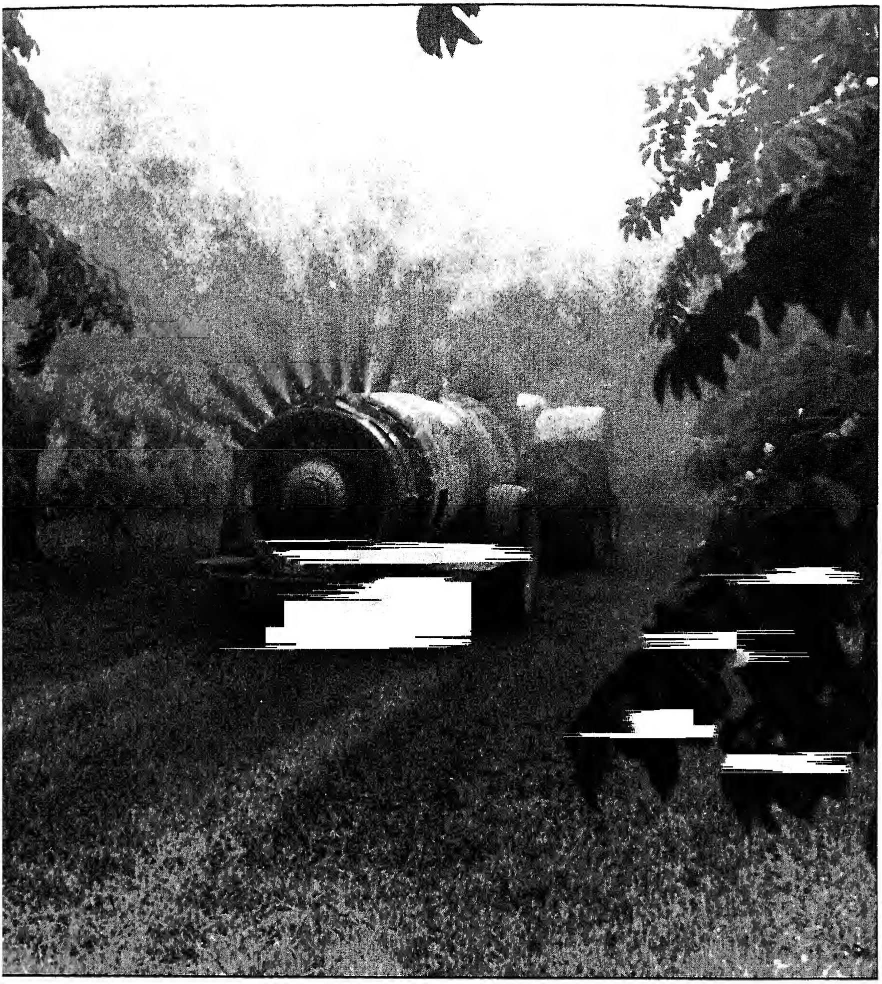
Research over the past 50 years has shown that plant growth is largely controlled by chemicals made by the plant. These "plant hormones" include five types of chemicals or chemical classes—auxins, gibberellins, cytokinins, ethylene and abscisic acid.

Plant hormones are made during growth and development of the plant and work together to modify or regulate such physiological and biochemical processes as cell division and enlargement. Although the hormones have been known for half a century, the exact mechanisms of this action remains a mystery. Many scientists think that plant regulators made by chemists act, at least in many cases, by modifying the activity or production of the natural plant hormones.

Research is being undertaken to learn more about natural growth chemicals and systems in order to develop new synthetic chemicals and management techniques. Better control of plant behavior will increase agricultural production—and production efficiency.

Plant growth-regulating chemicals have been used on a number of high value or specialty crops since the 1930's. Growth-regulating chemicals developed since that time have been used mostly on horticultural rather than agronomic crops.

Regulators are used to promote rooting of cuttings; modify development of flower buds; influence breaking or initiating dor-



A few days before harvest, ethephon — which breaks down into ethylene gas — is sprayed on cherry trees. The chemical loosens the cherries and reduces harvesting time.

mancy in seeds, tubers and buds; control fruit set, size and color; modify plant size and shape; inhibit sprouting to prolong keeping quality; facilitate mechanical harvesting; prevent loss of yield by keeping plants upright, and induce plant leaf drop.

One of the most versatile plant growth regulators to be discovered over the past few years is an ethylene releasing agent called ethephon. It has long been known that the relatively simple gas, ethylene, is capable of affecting growth of plants as well as ripening of fruits such as bananas. Discovery of a chemical that

could produce or release ethylene after it was applied to plants made it practical to treat field-grown plants with ethylene.

Because of the many responses obtained from treating plants with ethephon, the concept of chemical plant growth regulation became a real possibility in the minds of many scientists. Since ethylene is a natural constituent of plants, responses obtained with ethephon are believed to occur through existing natural pathways.

New responses of potential importance to agriculture are being found with ethephon but many in commercial use today are associated with the improvement of crop harvesting efficiency. Ethephon promotes earlier coloration and maturity of apples, tomatoes, peppers and cranberries. It also loosens cherries, walnuts and applies for earlier and more efficient harvest. More blueberries get ripe at one time, and blackberry ripening is accelerated and berries loosened for easier harvest.

Ethephon is used on such specialized crops as figs to accelerate early uniform ripening and on filberts to hasten husk maturity for earlier and more efficient harvest. Applied to cucumbers and squash, ethephon increases the number of female and decreases the number of male flowers, which makes it easier to produce hybrid seed of these crops. In Europe ethephon prevents winter barley from lodging so grain is not lost at harvest time.

Most people have a good idea of what drought can do to plants. Such stresses as lack of water, low humidity, and excessive water, heat or cold directly affect crop yields but chemicals may help reduce some of the adverse effects.

Because world population is increasing and because less suitable land areas must be used for agricultural production, plants need to be better adapted to an ever increasing range of stresses.

Low concentrations of air pollutants in certain agricultural regions may adversely affect crop yields. A newly discovered experimental compound has been found to protect plants against damage from ozone, a widespread and troublesome air pollutant.

Another group of chemicals has been discovered that increases plant susceptibility to low temperatures but confers resistance to high temperature stress. Research shows that these type compounds change chemical composition of cells which in turn alters resistance to environmental extremes. Research is being conducted to determine if these regulating chemicals can be used to extend the production area of plants that do not tolerate heat well. Application of such chemicals to weeds, on the other hand, may make them less tolerant to winter cold so they do not survive to grow again in the spring.

One can easily think of a wide range of plant responses that we would like to control to increase the usefulness of plants to man. From the few examples cited, we can get some idea of the probability of discovering chemicals that will modify plant growth without adversely affecting the consumer or the environment.

The future for plant growth regulators is bright but much is unknown. Further research into how plant growth and development is controlled is needed for use as a basis for discovering new and more effective plant growth regulators. However, plant growth regulators now in use have made agricultural production much more efficient.

By George L. Steffens, Plant Physiologist, Agricultural Research Service.

Multiplying Fruits and Berries

It is a lifelong project to develop and test a new fruit tree. Small fruit varieties such as blueberries may require 15 to 18 years. Even new strawberry varieties require 10 years to develop. But a new method for multiplying plants is changing all that. Tissue culture propagation is cutting the time it takes to get new varieties of fruits and berries to the grower by 30 to 50 percent.

Tissue culture propagation is a technique by which small pieces of plant tissue are placed in a carefully formulated, sterile growth solution. Plant hormones incorporated in the solution force the tissue to develop many shoots. The shoots can then be transferred to a different growth solution containing hormone levels that promote rooting. The rooted plantlets are transferred to soil and adapted to outdoor growing conditions in the greenhouse.

In this manner, any number of plants of a given variety can be produced within one year after the variety is introduced, or, in the case of imports, released from quarantine.

For example, new everbearing strawberries are currently being increased by tissue culture for distribution to nurseries. In six months tissue culture can produce five or six thousand plants each of which can be multiplied by 20 in the field, providing 100,000 plants within one year. It would take at least 3 years by conventional propagation.

In addition, the new plants will be healthier. Most cultivated fruit-producing plants have one or more viruses which are not readily visible but which decrease yield. However, cells in a plant's

growing tip are not "old" enough to have been infected. When one-half millimeter (1/50 inch) or less of this growing tip is cultured and generated into new plants, the plants are usually free of viruses. Tissue culture is the only method capable of producing the large numbers of virus-free strawberries required by growers each year.

Also, tissue culture is causing a revolution in the orchard. All production techniques used in orchards today were developed during the last two decades, with the exception of propagation. Propagation by grafting is at least 2,000 years old. The Apostle Paul spoke about branches that had been grafted onto the olive tree. In the first century A.D., Pliny described cleft grafts as practiced by the Romans.

From the 16th and 17th centuries, we have illustrations of grafting that are very similar to those we would make today. Fruit bearing trees were selected for fruit quality and productivity, not for their ability to develop roots. As a result, their cuttings must be grafted onto rootstocks which is time-consuming and labor-intensive. Tissue culture, however, allows the use of hormone concentrations that promote the rooting of plantlets.

The capabilities of tissue culture are well matched with current interest in high- and ultra high-density orchards. Trees in such orchards are planted close together, are pruned by machines, and are short-lived compared to those in conventional orchards. Tree requirements for such orchards are high; occasionally as many as 4,000 trees per hectare or 1,600 trees per acre are needed.

With present propagation practices, the cost of trees is an obvious limiting factor for high density planting. This cost is increased even more by the fact that high density orchards may last only a relatively short time, often no more than 10 years.

Fortunately, tissue culture has the potential to produce high quality trees relatively inexpensively. It is possible that growers may buy small treelets 5 to 10 inches tall, grow them for a year in their own nursery, and plant them in their permanent place mechanically.

Life in the orchard and the berry patch will never be quite the same because of tissue culture. The revolution is well in progress.

By Miklos Faust, Plant Physiologist, Agricultural Research Service.

Better Meat, Eggs and Milk for Our Tables

Coordinated by C.W. Absher and T.H. Blosser

Farm animals help Americans be among the best fed people in the world. Animals provide two-thirds of the protein, a third of the energy, four-fifths of the calcium, and two-thirds of the phosphorus in our diet. In addition, animal food products are important sources of iron, Vitamin A, thiamine, riboflavin, and Vitamin B6, and are the sole source of Vitamin B12.

Animal production enterprises are a major source of U.S. farm income. About 52 percent of total farm income is generated in the pastures, feedlots, swine and poultry houses, and milking parlors of America.

Animals also contribute to the well-being of man by supplying leather, wool, feathers, and even horns and bone for clothing, adornment, or use in tools and implements. Also essential to man are products used in maintaining health such as insulin. Animals provide some power and entertainment and enjoyment for many.

But animal agriculture and livestock producers, like other sectors of our economy, must become more efficient to survive the price-cost squeeze and to keep animal products available. The search for ways to improve the efficiency of production and to safeguard the animal population is a major task of the U.S. Department of Agriculture and its cooperators in the State Agricultural Experiment Stations, Cooperative Extension Services, and related industry.

Modern animal agriculture is the product of achievements by many persons working in many areas. This chapter contains only a few of the advances that have been made or that are underway, aimed at achieving optimum efficiency in agriculture.

The reader is invited to consider these brief reports as small windows or peepholes into the world of science and education—relative to animal production.

Hopefully, you will recognize that just finding an answer is not enough. The scientific community must also attempt to refine the questions and get answers applied. Selected accounts of these attempts follow.

Coordinators of this chapter are Curtis W. Absher, University of Kentucky, on assignment to the Extension Service, USDA, and Timothy H. Blosser, Agricultural Research Service, USDA.

The Computer and the Cow

Joe Livestockman finishes breakfast and picks up the telephone. But he is not calling a neighbor, veterinarian, or equipment dealer. Instead he calls a computer center.

A computer answers at the other end and Joe attaches his tele-

phone receiver to a small computer terminal about the size of a typewriter. He is now in direct communication with the central computer.

By typing in the names of various programs on the terminal keyboard, he can access a myriad of management aid programs designed by extension and research personnel at various institutions around the country. These include feed formulation, performance data, health and reproduction records, budgeting, enterprise accounting, performance and economic projections, marketing, and many others.

Today Joe is formulating a new ration for his milking cows. Available feed ingredients and their prices per ton are: corn grain, \$146; barley, \$138; citrus pulp, \$120; cottonseed meal, \$180; whole cottonseed, \$180; soybean meal, \$280; and wheat millrun, \$130. He also has homegrown alfalfa hay and corn silage which are worth \$84 and \$25 per ton.

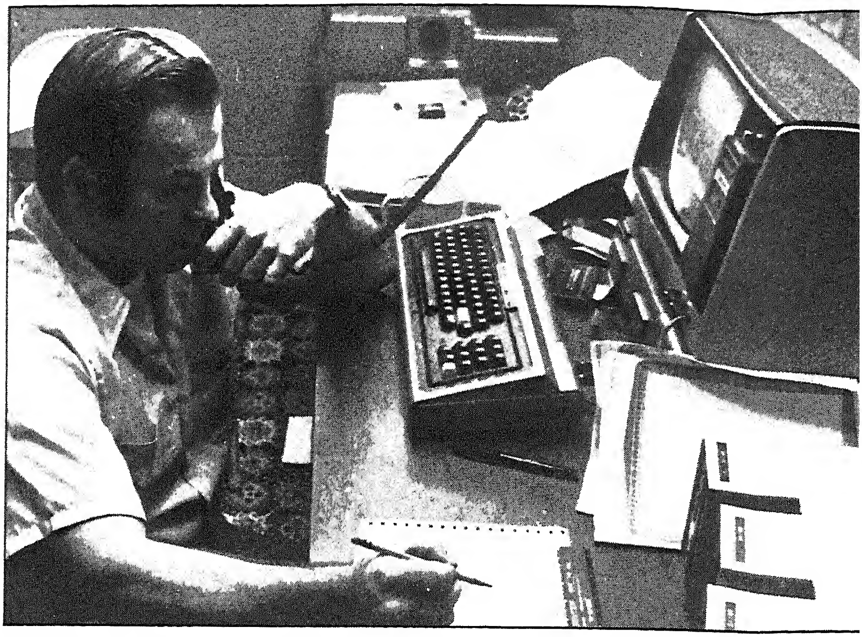
Which ingredients should he feed to his cows to obtain maximum profitability from his herd? The computer gives the answer.

Joe enters the prices of available feeds, average cow size and milk fat percentage, milk price and level of milk production. The computer does the rest. It tests every combination of available feed ingredients which fulfill the nutrient requirements of the cow, and prints out the formula of the ration which minimizes feed cost or maximizes income above feed cost, depending on the program used. It also lists feeds not selected for the optimum ration and the price they would have to drop to before becoming good buys.

The computer calculates expected milk income based on current milk price, feed cost based on prices of feeds selected for the ration, and calculates expected income above feed cost by difference.

In this example, the computer recommends a ration consisting of 25 pounds corn silage, 18 pounds alfalfa hay, 6.6 pounds corn grain, 5.5 pounds citrus pulp, 5.5 pounds wheat millrun, and 4.2 pounds whole cottonseed. Cows consuming this ration should produce 56 pounds of milk, which at \$13 per hundred-weight returns \$7.28 per cow per day. Cost of the ration is \$2.61 per cow, leaving an income above feed cost of \$4.67 per cow.

Joe repeats the process for several other levels of milk production. When he finishes, he hangs up the phone and has a feeding



Computers will play an increasingly important role in helping farmers make management decisions. In the near future, many will have micro computer centers in their homes.

program tailored specifically for his herd, based on his input data. And he knows that the rations formulated are well-balanced nutritionally as well as being economically optimum.

Later, Joe may dial the computer and request a list of cows that are due to be bred, a list to check for pregnancy, a list of potential cull cows based on his performance criteria, a ranking of all cows in the herd based on milk production or profitability, or many other management reports generated by the computer from monthly testing of his cows through the Dairy Herd Improvement Program.

He also can get lists of sires evaluated according to milk transmitting ability, physical traits, or calf birth weight. In addition, complete health and reproduction histories are available for all animals in his herd.

The computer can do all these things quickly and accurately and is a wonderful aid for decision making. However, the information that comes out is only as good as the input data that goes in. But with good input data, Joe knows that his management skills, and subsequently the profitability of his enterprise, are greatly increased by use of this modern tool—the computer.

By Donald L. Bath, Extension Dairy Nutritionist, University of California, Davis.

Poultry—A Cinderella Story

Farmyard scenes have changed considerably over the past half century, but the most dramatic change is with poultry. No more flocks of 100 or 200 hens scratching in the barnyard and going in to roost before sundown. No more dressing a couple of spring fryers early Sunday morning. No more eggs brought to the grocery store for credit to the family account.

Poultry historically was part of the family farm. Chicken and eggs (and even turkeys at times) were part of our heritage of being self-sufficient, just as were the milk cow, the pigs being fattened, fruit trees, and the vegetable garden. In general, each family produced what poultry products it could, ate what it needed, and sold what was left over.

But a few forward looking pioneers in the 1930's and 1940's decided it would be more economical to concentrate their efforts on one type of commercial operation and go all out to produce en masse and reduce expenses wherever possible. Feed, chicks, housing—all could be purchased cheaper in quantity.

Results of this particular approach is now quite obvious to us all. While other foods often cost more and more, chicken of the very best quality is being sold at 49¢ to 59¢ per pound ready to cook.

The entire poultry industry is a far cry from what it used to be. Eggs are produced under controlled conditions by hens capable of laying over 250 eggs each per year. These eggs are uniform, of excellent quality, and reach consumers within two to five days at a bargain price (less than 70¢ per pound). Since they are produced year-round, cold storage is used only for brief periods (less than 48 hours) as eggs move through marketing channels.

Broilers are produced on highly specialized farms that do little else. Specially bred birds are fed rations formulated to produce optimum growth, uniformity, quality, and even the most desirable skin color in less than eight weeks on two pounds of feed for each pound of chicken. The birds are processed completely even to being cut up, deboned, and packaged prior to distribution for consumer purchase.

Low production and processing costs allow the modern broiler chicken to be sold as a real bargain to consumers, who use almost 50 pounds per person every year.

Turkeys are an equally phenomenal story. Modern turkeys are white feathered, of such broad meaty conformation that they can't even mate naturally, and reach market weights in 14 to 22 weeks of

Broilers have become one of America's favorite foods. These specially bred birds reach market weight in about eight weeks. Americans consume 40 pounds of broilers each year.

age on three pounds of feed per pound of turkey. They are grown in flocks of 5,000 to 50,000, many in total confinement.

Turkeys are processed as whole birds, boneless roasts, turkey parts, turkey ham, or used in luncheon meats and many other oven-ready and table-ready products. Consumption is more than 10 pounds per year for every American.

These successes in American agriculture have been achieved through a partnership effort. Research has led the way by providing the basis for making changes. Ideas that researchers developed have been taken by industry and turned into efficient production and processing technology. Disease problems have been greatly reduced by vaccines such as Marek's disease vaccine and live cholera vaccine developed under U.S. Department of Agriculture programs.

Extension has joined researchers in taking research and applying it to commercial conditions. This partnership of research, Extension, and industry has made the poultry industry a shining example of government programs and the free enterprise system.

By Ken A. Holleman, Program Leader, Poultry Science, Extension Service.

Embryo Transfer

Cattle breeding's most exciting development in decades is embryo transfer. Normally, a cow has only one calf per year (a few percent have twins), but with embryo transfer it is not unusual for a cow to be the genetic mother of 10 calves born within a few days of each other.

The principle of embryo transfer is to remove the developing embryo from the uterus of a valuable cow about one week after conception, and transfer it to the uterus of a less valuable cow for the remaining nine months of gestation. Thus, the genetically valuable donor cow can become pregnant temporarily during each three-week reproductive cycle.

In practice, the procedure is modified by treating the donor with a fertility drug, such as follicle stimulating hormone. This is termed superovulation and causes an average of 6 to 8 embryos to be produced instead of the usual one. Superovulation can be repeated about every two months.

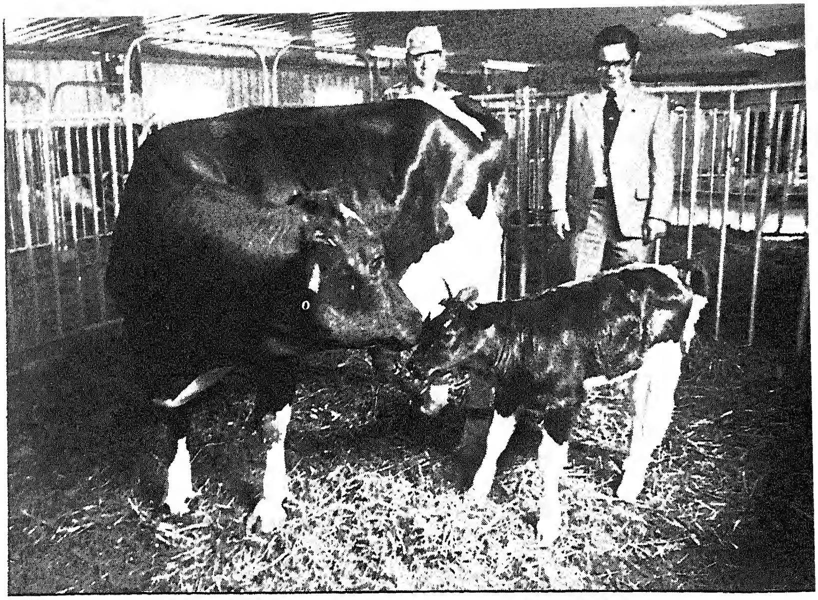
Embryos are recovered from donors by flushing the uterus with large volumes of fluid. The flushing apparatus is inserted into the uterus in the same way as an artificial insemination pipette. The embryos, about 1/200th of an inch in diameter, are found in the fluid with the aid of a microscope and can be manipulated with small glass pipettes.

Embryos can be stored for about a day in an incubator with little loss in viability, or they can be frozen to −196°C in liquid nitrogen. The freezing and thawing process kills nearly half of them, but permits storage of the viable ones for decades.

For high pregnancy rates, the recipients, or surrogate mothers, must be at about the same stage of the reproduction cycle as the donor. Embryos are usually transferred nonsurgically with artificial insemination equipment. But pregnancy rates are slightly higher if they are transferred surgically through a small incision in the flank of the recipient under local anesthesia. With the surgical method, about 60 percent of recipients become pregnant, which is similar to the pregnancy rate following normal breeding.

Embryo transfer currently costs $500 to $1,500 per pregnancy more than conventional reproduction. Providing such services has become a large, fast-growing industry. About 25,000 calves will be born as a result of this technology in North America in 1981.

Major use of embryo transfer is to amplify the reproduction rates of valuable cows. On the average, 3 to 4 calves are obtained from



A surrogate mother checks out her newly born calf, the result of an embryo transfer from another cow. Through this practice the embryos from a high producing milk cow can be transferred to as many as 10 less valuable cows, resulting in 10 genetically superior calves born within a few days of each other.

each embryo collection and, on rare occasions, up to 20 or more.

Another use is to obtain calves from otherwise infertile donors. Such infertility is usually due to a senescent uterus; it is circumvented by transferring the embryos to a younger uterus.

A third common application is exporting embryos, which involves much less cost as well as less risk of transmitting disease than exporting live animals.

Embryo transfer techniques have been used in many species, including humans. The most important commercial species after cattle are horses and pigs, although a small amount of commercial work is also done with sheep, goats, and rabbits.

Many future technologies will depend on embryo transfer, including cloning. Procedures which already work in the laboratory include sexing the embryos, fertilization in a test tube, twinning in cattle by transferring two embryos, and even dividing embryos in 2, 3, or 4 parts to produce identical twins or multiplets. It is likely that some or all of these procedures will be used commercially in the next decade.

By George E. Seidel, Jr., Associate Professor, Reproductive Physiology, Colorado State University, Fort Collins.

The Silent Killer

During the last several years porcine parvovirus (L parvus = small + virus) has been recognized as a major cause of maternal reproductive failure of swine. Through laboratory and field studies it has been shown that, when a nonimmune female is exposed to porcine parvovirus during gestation, the virus is frequently transmitted from her tissues to one or more of her litter of unborn pigs (fetuses).

Although the affected female is usually free of any outward clinical signs, fetuses are killed by the virus if they are infected any time before they are about 70 days of gestational age. Fetuses infected thereafter usually survive by developing an immune response similar to that of a baby pig.

If a fetus dies very early in gestation, it is resorbed, that is, disappears without leaving any trace of its former presence in the uterus. If it dies after its skeleton begins to form at about 30 to 35 days of gestation, it becomes dehydrated and is said to be mummified. Mummified fetuses are usually retained in the uterus through at least the normal interval of gestation (about 114 days).

Each pig fetus is enclosed in its own protective sac so that infection of one fetus does not necessarily result in infection of any other. Therefore, it is not uncommon for an affected litter to have both mummified and normal fetuses. A swine producer may have no indication that his pregnant sows have been affected by porcine parvovirus until they either fail to farrow (if all their fetuses were resorbed), or farrow unusually small litters, or farrow mummified fetuses.

In many parts of the world, including the United States, porcine parvovirus appears to be the most common infectious cause of maternal reproductive failure of swine—causing an estimated $25 to $75 million annual loss to U.S. swine producers. The virus has been found among swine throughout the world. In this country, it is present in almost all herds.

Although porcine parvovirus was first recognized as a pathogen of swine less than 15 years ago, we now know—through research within the U.S. Department of Agriculture and elsewhere—most characteristics of the virus and the disease. Such research has recently culminated in development of safe, effective, and inexpensive vaccines. Control of this disease through vaccination is but another example of cooperative efforts by government and industry

to most efficiently produce pork and pork products for the American consumer.

By William L. Mengeling, Research Leader, Virological Research, Agricultural Research Service, USDA, Ames, Iowa.

Virus Controls Cancer

The concept of protecting one animal by a virus from another originated with Jenner in 1798, when he noticed that milkmaids survived epidemics of smallpox. He was able to demonstrate that the cowpox virus produced little or no disease in humans, yet protected humans from smallpox.

This observation led to use of cowpox in humans as a highly successful vaccination against smallpox to this day. The concept also has been the basis for recent development of a commercially-produced, Federally-licensed vaccine for cancer in chickens, the first for cancer of any animal.

A cancer affecting chickens called "Marek's Disease" has been the most commonly occurring cancer in the world. Before the vaccine was developed, almost all chicken flocks were affected, and in some instances over half the flock died. The cancer can now be prevented by a highly effective vaccine which is administered to most chickens in developed countries throughout the world.

Marek's Disease was named after a Hungarian veterinarian who described it in 1907. The disease has been recognized in most countries of the world.

In the 1950's a severe form of the disease appeared on the East Coast of the United States and spread gradually over the country, causing many deaths and production losses in layers and broilers. Also, broilers that are unfit for human consumption because of the presence of tumors are "condemned" at the processing plant even though contact with chickens or poultry products from birds with Marek's Disease has never been shown to cause cancer in man.

Marek's Disease is caused by a virus that infects only certain species of birds. This virus is related to viruses causing cold sores and mononucleosis (mono) in people. The virus of Marek's Disease is spread from an infected chicken to a noninfected chicken through the air. Most commercial chickens become infected with the virus when very young.

Cancer research is difficult and very time consuming, even in chickens. The time between infection with the virus and tumor development is variable and can be quite long (1 to 30 months).

Research on the chicken disease was started by the Federal government in 1939, but it was not until 30 years later that the causative virus was identified. It was during studies on determining which birds other than chickens could harbor Marek's Disease virus that a similar virus was isolated from turkeys.

The virus looked like Marek's Disease virus though distinguishable from it. It was determined that the turkey virus caused no disease when inoculated into chickens; in fact, when inoculated into chickens it protected them from developing Marek's Disease.

Herpesvirus of turkeys, as it is called, was shown to be a highly effective vaccine against Marek's Disease. It was licensed for use in the United States in 1971 and is now used worldwide. The vaccine reduced losses from Marek's Disease to the poultry industry by over 95 percent.

In 1974, the first year of full adoption of the vaccine, it is estimated the vaccine saved $628 million. Each year thereafter the saving has been put at over $168 million. This represents savings to the consumer of over 2¢ per dozen eggs and almost 6¢ per pound of broiler at the supermarket from this disease alone.

By H. Graham Purchase, Acting Chief, Livestock and Veterinary Sciences, Agricultural Research Service.

Matching Breed and Feed

American cattlemen can draw upon a vast array of feed resources and cattle breeds for producing beef. Stocking rates range from one cow per two acres or less to only one cow per 300 or 400 acres because of differences in climate, land, and feed resources. The challenge is to match breeds of cattle having diverse performance characteristics with the highly variable resources on farms and ranches to make beef production as efficient as possible.

Differences between breeds in production characteristics are real. Generally, faster gaining breeds have heavier birth weights, more calving difficulty, and greater calfhood death loss. However, faster gaining breeds use feed more efficiently in the feedlot and produce leaner carcasses. Differences among breeds in tenderness, flavor, and juiciness of meat are small. Breeds that gain rapidly often are slower to reach sexual maturity.

A cow herd should consist of breeds well adapted to the specific farm or ranch where they are produced. Research shows that reproduction and production efficiency are reduced when the additional feed required by larger, heavier milking cows is not supplied.

Just as engines that vary in horsepower and performance require different quantities and quality of fuel for optimum efficiency, so cattle that vary in performance have different feed requirements.

These differences among breeds can be exploited by use of breeds 1) as straightbreeds, 2) in systematic crossbreeding programs, or 3) in developing new composite breeds.

Straightbreeding (use of a single breed) is the easiest breeding system to manage. Selection of breeding stock that is better adapted to the environment is a slow process but the only tool for genetic improvement available to the producer using straight-breeding.

A systematic crossbreeding program that combines the benefits of selection with the advantages of crossbreeding (hybrid vigor) can be used to match breed characteristics with the climatic-feed environment. Production per cow is increased 23 percent by crossing European breeds. Crosses between Brahman and European breeds yield even higher levels of hybrid vigor.

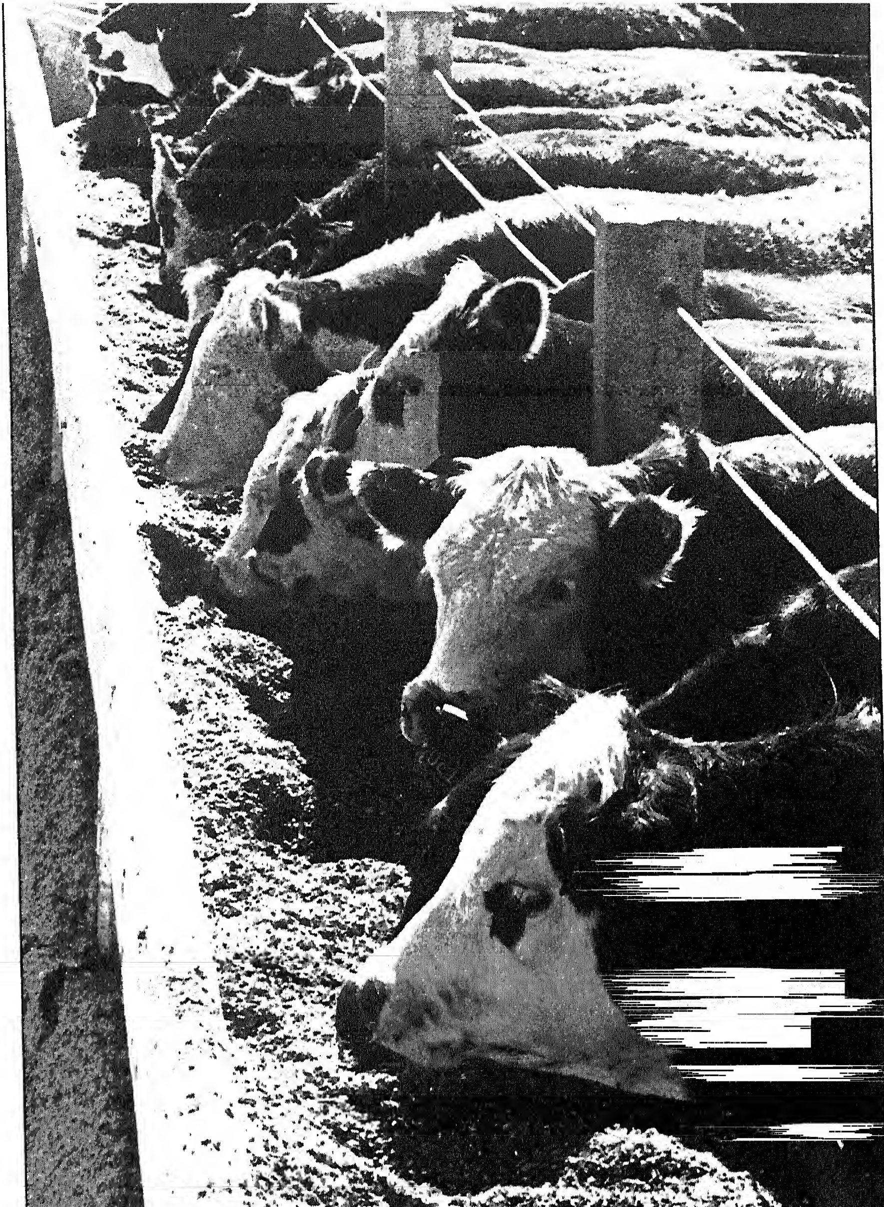
A variety of crossbreeding systems are employed. Rotational use of purebred bulls of two or more breeds maintains much of the hybrid vigor. Efficiency is maximized by crossbreeding systems that involve crossbred cows of small to medium size and optimum milk production mated to sires of a breed noted for large size and carcass leanness. Systematic crossbreeding can be complicated, however. Bulls and cows of specific breeding and separate breeding pastures must be maintained.

An alternative to the complex systems of crossbreeding is use of a composite breed developed by intermating animals from two or more breeds. For example, the Santa Gertrudis (⅝ Shorthorn, ⅜ Brahman) and Brangus (⅝ Angus, ⅜ Brahman) are breeds developed from a crossbred foundation.

The primary advantage of using a composite breed is that after the formation stage, the population requires the same management as straightbreeding. Composite breeds may allow producers with small herds to reap some of the benefits of crossbreeding. By careful selection of foundation breeds, composite populations can be developed that are adapted to a variety of nutritive and climatic environments.

Research is in progress to determine the level of hybrid vigor that can be maintained in composite breeds and to compare composite breeds with crossbreeding systems.

By Larry V. Cundiff, and R.L. Hurska, U.S. Meat Animal Research Center, Agricultural Research Service, USDA, Clay Center, Nebr.



At the U.S. Meat Animal Research Center, Clay Center, Nebr., crossbred cattle are being tested to see which breed crosses gain most efficiently.

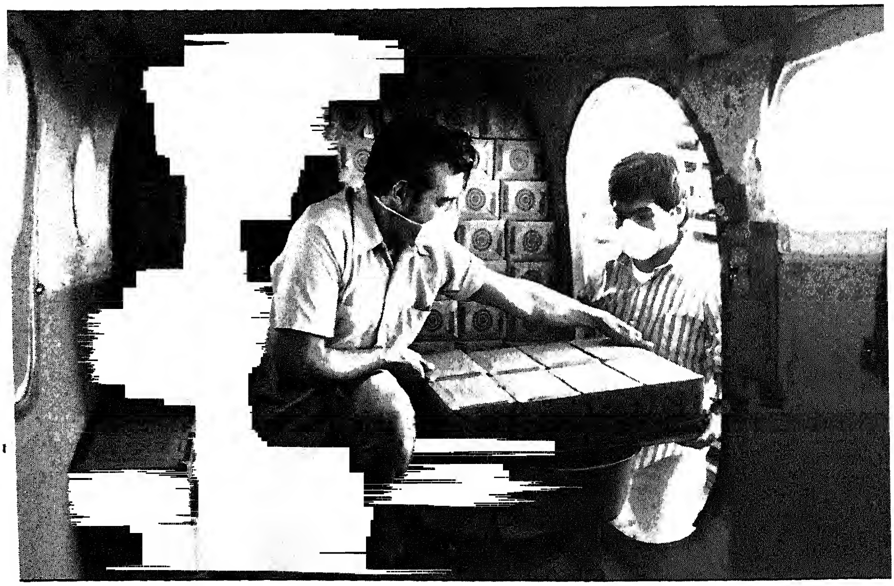
Atoms and the Screwworm

Over 100 years ago, as the livestock industry struggled for survival in the Southwestern United States, ranchers had to protect their animals from many diseases and parasites. One of the most feared was the screwworm—the larval stage of a blue-green blowfly.

This insect had long been known in tropical regions of the New World but is believed to have spread to the United States sometim after Spanish cattle were herded to Texas and other Southwester States. In southern Texas it passed the winter safely and each spring and summer extended its distribution to Kansas or even farther north.

In 1933 screwworms appeared in Georgia and Florida and estal lished an overwintering population in southern Florida. Each spring thereafter adult flies moved north during the summer months to plague several of the Southeastern States.

Maggots of the screwworm grow only in healthy tissues of living animals, where they bore in deeply and consume the flesh. If an infestation is not checked, the host is often killed in one to two weeks.



Workers in Mexico load an aircraft with sterilized screwworm flies which will be released over infested areas. The sterile males mate with wild females whose eggs will not hatch.

The female fly deposits her eggs on fresh wounds of all warm-blooded animals, but the navel of newborn calves, fawns, and other young animals is an especially attractive site. The eggs hatch in less than a day, the tiny larvae bore into the exposed flesh, and more flies lay eggs at the edge of the infested wound. In this way, the infestation grows until thousands of maggots are actively feeding. The animal dies unless treated.

Prior to 1958, economic losses were tremendous. Livestock owners purchased large quantities of screwworm remedies, expended countless man-hours searching for and treating "wormies" as they were called, and still suffered the loss of animals either killed or maimed.

Losses varied with livestock prices but are believed to have sometimes exceeded $200 million a year in the zone from southern California to southern Georgia. One writer calculated that approximately 650,000 animals were killed by screwworms each year. Humans were not exempt; and prior to 1960, screwworm cases were reported quite regularly in medical literature. The problem in many Latin American countries was quite similar.

Fortunately the situation improved dramatically soon after a pair of Department of Agriculture entomologists, E.F. Knipling and R.C. Bushland, conceived a method of using the flies to destroy their own species.

Screwworm flies reared for that purpose were sexually sterilized by exposure to atomic radiation and then released in the field. The otherwise vigorous sterile males mated with wild females who then deposited eggs which did not hatch.

First proven on Curacao by A.H. Baumhover and other entomologists in 1954, the technique was used by State and federal veterinarians to eradicate screwworms from the Southeastern U.S. in 1958. Later the program moved to the Southwest; and in 1976, became a joint undertaking of two countries—Mexico and the United States.

The joint program has been so successful that in 1980 only two screwworm infestations were found in the entire United States. The pest had been reduced to similar very low levels in northern Mexico but the program will continue until it reaches the Isthmus of Tehuantepec in southern Mexico. There a permanent barrier of sterile flies will be established so as to protect screwworm-free territory from reinvasion.

Savings already produced by this amazing program are shared by consumers as well as producers. In 1972 it was estimated that an additional 380 million pounds of carcass beef were available to

American consumers because cattle survived which had previously been killed by screwworms.

Sportsmen have also benefited as more deer and other wild animals were available to hunters in Southern States; previously 25 to 75 percent of the fawns in the screwworm over-wintering region were killed by screwworms.

The benefits of screwworm eradication have exceeded its costs 100-fold—a truly remarkable example of progress in scientific agriculture.

By O.H. Graham, Research Entomologist, Agricultural Research Service, USDA, Mission, Texas.

Residues and Ruminants

Ruminants are unique. They don't have to compete with humans for food. Cattle, sheep, goats, and other ruminants have specialized stomachs containing tiny microorganisms which enable them to digest and utilize fiber. While some fiber is beneficial in the diets of humans and other monogastrics such as pigs and chickens, fiber cannot meet a very large part of their energy needs.

Fiber is the most abundant nutrient on earth. All plants contain large amounts of fiber and generally only the grain (seed), fruit, or tuber is high in sugar or starch. When grain is harvested, an amount of high fiber residue remains in the field equal to the amount of grain harvested. There is enough residue from grain production to feed the entire beef population in the United States.

Why haven't we been feeding more plant residues? Primarily because grain and traditional forage supplies have been plentiful. Large amounts of grain have been used for fattening beef cattle.

However, this is all changing. Leaner beef has been requested by the consumer. At the same time grain is being preferentially used for direct human consumption, for feeding to pigs and chickens, for export, and for fuel alcohol production. Traditional forages will be well-utilized but acreages will not increase because of the need for grain production.

The time to use plant residues for cattle production has arrived. In many parts of the western Corn Belt, the common system of winter feeding of beef cows is to allow them to graze cornstalk fields. Little cost is charged to the cattle because it was charged to the grain produced. Also, the cattle pay their own harvesting cost!

What are the limitations to plant residue use? Because the plant is mature when the grain is harvested, it has rather low quality.

Weather prohibits grazing in many areas for extended periods. Some or all of the residue must remain on the soil to prevent soil erosion and maintain tilth.

Agricultural research is helping solve many of these problems and to enhance utilization of plant residues—especially for beef cattle.

Two primary approaches have been taken to improve the quality of plant residues. The first is to optimize management systems and plant varieties to produce better quality roughage. Time of harvest has been shown to be extremely important. Moisture level during the growing season affects residue quality, and currently used corn varieties vary in the quality of residue they produce.

The second means of improving crop residue quality is through treatment with chemicals. Research has shown that three simple, widely used and relatively safe chemicals increase the digestibility of crop residue fiber. These chemicals are sodium hydroxide (lye), calcium hydroxide (lime), and ammonia.

Corn cobs mixed with sodium hydroxide and lime have feeding value equal to high quality corn silage, but no grain is fed! Wheat straw, previously used for bedding, can meet the nutritional needs of gestating beef cows when treated with ammonia.

The potential for use of ammonia is very exciting because it is effective in increasing digestibility, residual nitrogen can be used by microorganisms in the cattle to make protein, ammonia is easily distributed to the farm just as it is for fertilizer, and treatment with ammonia is simple.

Wise application of these technologies can help maintain beef production with greatly reduced dependence on grain feeding. This will allow us to have our steaks and hamburgers and not compete with grain used in other high priority areas.

By Terry Klopfenstein, Professor, Animal Science, University of Nebraska, Lincoln.

More Milk, Half the Cows

Finding and caring for a good dairy cow—one that gives a lot of milk—used to be a very risky hit-or-miss game. Merely 40 years ago, cows giving 2 or 3 gallons of milk a day were considered satisfactory by most farmers. Today, 7 gallons, or about 120 glasses a day, is more the rule. This increase in milk per cow didn't just happen; it was the result of cooperation among a team made up of farmers, extension workers, researchers, and educators.

How did this tripling of milk per cow come about in the past few decades? First, the team set up procedures for finding high producing cows and high producing herds. Through the National Cooperative Dairy Herd Improvement Program, milk yields were recorded for cows in many herds across the country.

Second, researchers and extension personnel studied those cows that gave the most milk, as well as herds where all cows produced well. They investigated the high producing cows thoroughly: what they ate, how they were cared for, and their ancestry. Experiments were conducted in university or other research herds to verify usefulness of the insights gained from observations of farmers' high producing cows.

Third, educators and extension personnel shared with farmers and others involved with dairy cows the techniques proven effective to increase milk production and efficiency.

What have been the benefits of more milk per cow? Today a little over 10 million cows produce the Nation's milk—more total milk than the 20 million cows then in the United States produced in 1950. Because a lot of the cost of a cow is the feed and labor needed to maintain her, fewer but higher yielding cows mean lower priced milk to consumers.

Genes from the superior American dairy cows are being used worldwide today to improve the availability of milk's nutrition to the world's hungry people.

Today we continue to monitor milk production through the National Cooperative Dairy Herd Improvement Program. Based on its data, programs have been developed to recognize and spread the genes from the very highest producing cows throughout all herds. Feeding programs that are more cost effective also are based on its data. Verification of the effectiveness of new production practices is continuous.

Since high milk production is the result of many things, both large and small, the continuous monitoring is a key ingredient to high production. This is necessary so insidious problems can be recognized and corrected before they cause serious losses. Cows in herds enrolled in the National Cooperative Dairy Herd Improvement Program produce 12 more glasses of milk per day than those not members.

It is likely that our future cows will give even more milk, especially if the proven programs of the past are continued. Researchers are continually discovering better ways to feed and care for cows, to control disease, to enhance reproduction, and to recognize those cows who will be the best parents of future generations.

'hrough the National Dairy Herd Improvement Program, many of he Nation's dairy farmers have been able to greatly increase milk ›roduction. The 10 million dairy cows on American farms today ›roduce more milk than 20 million cows did in 1950.

In recent years, some cows have produced over 5,000 gallons or 30,000 glasses of milk in a year—more than three times the yield)f today's average cow and a feat thought impossible by many a lecade ago.

The keys have been techniques for identifying cows with a superior "will to milk," the factors that enhance their ability to do so, and communication of these findings to farmers.

By Ben T. McDaniel, Professor, Animal Genetics, North Carolina State University, Raleigh.

More Mileage From Silage

Making hay when the sun shines is an effective way to provide winter forage for feeding cattle and sheep.

But to insure availability of forage for animal feed throughout the year, it is necessary to use some method of preservation and

storage. What's more, it is desirable to harvest forage when the nutrient composition is maximum to provide the best quality feed. Important methods are field drying for hay, artificial drying for hay, and ensiling.

Traditionally, sun-cured (or field-dried) hay has been and still is the most popular method of forage preservation. But when the weather doesn't cooperate, making hay is wasteful and frustrating. Therefore, increased use of ensiling will increase the preservation of forage energy and make the energy more valuable. New methods of forage preservation have reduced energy loss of the forage crop from an average of about 25 percent down to about 15 percent.

These new chemical methods of preserving forages are one step in improving forage preservation and utilization. Over the last two decades, ensiling has been improved by physical techniques such as wilting (partially drying) green hay-crop forages and ensiling them at about 35 percent dry matter as is usually done for corn silage.

Acidification with mineral acids at ensiling is an old technique for preserving hay crops but recent research has shown that formic acid, an organic acid, is very effective. Energy loss can be controlled to about 15 percent when fresh forage is ensiled with acid immediately after cutting.

Adding one-half percent of 90 percent formic acid solution is adequate for preserving most forages. There is no energy loss in the field because cut forage is immediately preserved by field application or application as the forage is put into the silo.

Formic acid makes harvest time less weather-dependent since moisture content of the forage will not affect ensiling. This means that harvest can be scheduled for maximum quality of forage with minimal consideration of weather. Harvest can actually take place during a light rain if the field is not too soft for the harvesting equipment.

Feeding of forage harvested as untreated direct-cut silage normally results in low consumption and growth rate by growing cattle. Besides, much protein in forage is degraded during ensiling and accounts for reduced animal performance. Formic acid treatment of direct-cut forage produces silage that gives excellent intake, digestion, and growth rate when fed to cattle.

Formaldehyde treatment of the forage at ensiling will offer the most economical method for preserving protein in silage if approval of formaldehyde as an additive is granted by the U.S. Food and Drug Administration.

Research has shown that cattle (yearling Holstein steers or heifers) gain from 2 to 2¼ pounds daily when fed direct-cut alfalfa si-

lage as the only feed preserved with a combination of formic acid-formaldehyde. Orchardgrass treated in the same way gave gains of about 1¾ pounds per day. Alfalfa as forage is superior to grasses because alfalfa is higher quality nutritionally.

Corn, more than any other crop, is used for silage in the United States and ensiles efficiently without additives. Corn silage is low in protein, and various nonprotein nitrogen additives have been tried to increase its feeding value to cattle.

Ammonia added to the whole corn plant at ensiling provides the most economical source of nonprotein nitrogen. Ammonia also inhibits protein degradation during ensiling, and produces a more efficient energy fermentation—which means more energy is recovered from the silo. Ammonia improves stability of the silage at feeding time.

New preservation and storage processes available to farmers and ranchers today will make more high quality forage available for livestock feed.

By H. Keith Goering, Research Animal Scientist, Agricultural Research Service.

The Bull, Big as Ever

The bull engenders even today a sense of ferocious grandeur. The scent of charcoaled beef takes us back to the long lost bull cults of the Mediterranean basin and our pastoral nomad heritage where the mobile food reserve, cattle, were money. Our folk hero, the cowboy of the silver screen and now a part of high fashion, remains the centaur of the most prestigious occupation in agriculture, cattle breeding.

Today, cattle breeding is more exciting than ranging vast herds on buffalo land by holding the watering holes with armed cowboys. The future belongs to the beef breeder who uses breeding technology spawned by the computer age in a creative breeding program designed to make rapid genetic change in economic merit. Intelligent technology application is the new frontier today in the beef industry that is so rich in traditions.

And the bull is still of paramount importance. The genetic problem of the beef breeder is to find bulls which when mated to the cow herd produce calves superior in economic merit to those produced by the current bulls. The solution to the problem is bull or sire evaluation done so that a large number of sires can be fairly compared on their breeding value, the value of a bull as a parent.

Fair comparisons among the progeny of a large number of sires are being made in nine breed-wide national sire evaluation programs run by the respective breed associations. The programs all follow guidelines of the Beef Improvement Federation in that reference sires are used as the means of making fair comparisons among the progeny performance of the sires.

When reference sire progeny are produced in two or more herds, the sires producing progeny only in one herd can be compared with sires producing progeny in other herds.

Analysis of data that predicts future performance of sires based on the number and performance of available progeny is conducted on large computers capable of solving large systems of linear equations. The latest technology available in statistical estimation theory is used to develop these equations. Thus, the cattle breeder is on the front line of technology development since each analysis of performance data requires new theory use and development.

Improved sire evaluation promotes use of the top sires in artificial insemination, making better reference sire ties and better data to analyze to make evaluations even more accurate.

Since sires are the critical issue in solving the genetic problem of beef breeders, these breed-wide national sire evaluation programs will enhance effectiveness of sire use in breeder herds. The programs being conducted by breed associations will help keep the breeds commercially oriented and available for straightbreeding or systematic crossbreeding by beef producers who wish to take advantage of hybrid vigor.

By Richard L. Willham, Professor, Animal Breeding, Iowa State University, Ames.

From Microbes to Meat and Milk

The ruminant has a remarkable approach to obtaining its protein supply. Much of the protein it consumes is destroyed in the first compartment of the stomach or rumen by the microorganisms which carry out a fermentative digestion. On average, only about 30 to 40 percent of the dietary protein escapes destruction and is available for absorption from the gut.

But the major source of protein for the ruminant consists of microbial cells produced in the fermentation. The microbial cells contain about 50 percent protein, and actually make most of this protein from degraded dietary protein.

The microbes eventually pass from the rumen to the intestine where they, like the kamikaze pilot, sacrifice for the cause. About two-thirds of the protein found in steak and milk resided at one time in microbial cells within the rumen.

There is both good news and bad news in this type digestive process. The good news is that low quality dietary proteins can be upgraded to high quality microbial protein. Also, the bacteria can use some non-protein nitrogen sources such as urea or ammonia. The livestock producer can substitute these inexpensive and readily available compounds for some of the dietary protein, thus lowering the cost of protein supplementation.

The bad news in microbial interaction in the digestive process is that the rumen microbes destroy more protein than they make under many feeding conditions, resulting in a net loss of protein. This is obviously expensive. As much as one-fourth of the protein fed to high producing dairy cows will be lost due to excessive destruction of dietary protein by rumen microbes.

The solution to this problem is to feed proteins less susceptible to breakdown by the rumen microbes. Some feedstuffs have naturally resistant proteins, such as brewers grains, distillers grains and corn gluten meal. Approximately half of the protein in these feedstuffs will escape breakdown in the fermentative digestion.

Some of the more important protein sources, however, are quite extensively degraded. Less than one-third of the protein in soybean meal, alfalfa, and cottonseed meal will escape destruction in the rumen.

Several approaches have been used to decrease protein destruction in the rumen. Heat treatment of feeds will lower protein losses, and presently there is commercial interest in marketing heat-treated proteins designed specifically for ruminants.

Chemicals such as formaldehyde and tannins have been used successfully to protect protein. But it is easy to overprotect protein, thus making protein unavailable for absorption from the gut. This results in rich manure and poor farmers.

There are several benefits from using naturally resistant protein or protected protein sources for our ruminant animals. These benefits are potentially available when feeding young growing ruminants or high producing dairy cows.

Feeding protected proteins, or "by-pass" proteins as they are called, can mean that less protein needs to be fed to obtain the same animal performance.

Another benefit from feeding relatively resistant proteins is that there will be greater opportunity for efficient use of nonprotein ni-

trogen in the diet. When there is extensive degradation of protein in the rumen, the rumen bacteria are more than satisfied with the resulting raw materials to make their body protein. They can't make use of the nonprotein nitrogen which may have been added to the diet. If less of the dietary protein is degraded, then the rumen bacteria need and do make use of the nonprotein nitrogen.

The goal of a protein-feeding strategy is to have most of the dietary protein escape destruction in the rumen and be used directly by the ruminant. Nonprotein nitrogen would be included in the diet for bacterial use and conversion to protein in the rumen.

The rumen bugs are our great friends—most of the time. They enable the ruminant to utilize fibrous feed, which people cannot use. They also convert low quality dietary protein into high quality microbial protein, thereby improving protein nutrition of the ruminant.

However, the rumen microbes are overzealous in their digestive activity when good quality rations are fed to highly productive ruminants.

Animal scientists are finding ways to sneak more dietary protein past our little friends in the rumen, and at the same time harnessing them to convert more nonprotein nitrogen into microbial protein. That means less costly and more abundant meat and milk for everyone.

By Larry D. Satter, Professor, Dairy Science, University of Wisconsin, Madison.

Calf Deaths Cut

The University of Idaho helped reduce calf death losses from 22 percent to 2 percent in multifarm demonstrations that applied modern management techniques.

A three-year study, the Pegram Exten-Search Project, involved three beef cattle ranches located near Pegram, Idaho, a ranching community in Bear Lake County near the Idaho-Wyoming border. The ranches had similarities in their family operations—all cattle grazed similar type summer range and the cow herd wintered at Pegram within a ten-mile area. The combined ranches managed 1,600 mother cows plus replacement heifers and summer yearlings.

Previous ranch records showed an annual death loss of 16 to 22 percent. The newborn calves were often born weak, became chilled, exhibited scours (diarrhea), and frequently died. Prolonged exposure to cold and extreme temperature variation further reduced the thriftiness of live calves, increasing their susceptibility to invading

disease organisms. Frequently, calves that survived the scours were usually set back in growth and did not fully recover their thriftiness.

Symptoms of diarrhea, fever, and dehydration were observed in sick calves. In many cases, calves did not respond to medication, thus increasing labor and adding more to treatment costs.

Primary objectives of the Pegram Exten-Search project were to recognize and define problems of the sick calves, and implement management changes to correct the problems and minimize death in the young calves. A secondary objective was to develop an effective and economical program in preventive medicine to improve thriftiness of the newborn calf.

During the three-year study, the University of Idaho staff, with cooperation of the Pegram ranchers, reduced calf death loss to 2.8 percent of all calves born during the calving period. This period began in mid-February and extended to the June 1 turnout on summer range.

Increased survival rate of calves born during the Pegram Project was attributed to a number of management changes and to improved calving techniques which had been applied by the ranchers, veterinarians, and University of Idaho staff associated with the project.

Management changes and calving techniques applied in the study included: sick calf treatment, nutrient fluid therapy, calving management and improved sanitation, herd health program, winter cow nutrition, improved calving facilities, herd health records, beef cattle improvement program, physical cow evaluation, and development of rancher skills.

The Pegram Exten-Search Project was funded by the Idaho Beef Council and conducted by the University of Idaho in cooperation with Pegram ranches. It focused on a total management systems approach to improving the reproductive efficiency of cow-calf range operations in Idaho.

Practical application of the Pegram information is being extended through calving management workshops and field demonstrations. The University of Idaho Cooperative Extension staff and practicing veterinarians utilize the support materials, audiovisual aids, and live demonstrations of the various techniques in a program thrust recognized by the Idaho Beef Cattle Industry as the Total Beef Program.

By Edward P. Duren, Professor and Extension Specialist, University of Idaho, Soda Springs.

Frontiers of Science to Tomorrow's Food

Coordinated by P.A. Putnam and J. McBride

Did you ever stop to think how tomorrow's food depends upon today's science? Feeding a burgeoning population while at the same time maintaining a favorable environment is the challenge of our agricultural scientists. Food production is not confined to an isolated segment of rural America but is an integral part of our country's socio-economic structure. As such, agriculture's future becomes our future.

Previous chapters have highlighted historical and contemporary accomplishments in food production which have resulted, in part, because of agricultural research—but what about tomorrow? What is likely to happen? Have we progressed to our biological limits for food production?

Answers to these questions in reverse order are that we have not reached our biological limits in science or in practice. Continuing increases in production and quality are anticipated.

Selected samples of a few of the changes and developments we may expect for tomorrow are described in the following vignettes. The topics were selected to illustrate how agricultural research contributes and relates to the other sciences, and how scientific advances in other fields are being applied to agriculture. This interaction among the sciences will help to assure that we have a plentiful food supply as we move into the 21st century.

Paul A. Putnam and Judy McBride, coordinators of this chapter, are with the Agricultural Research Service at Beltsville, MD. He is director of the research center and she is with the Northeastern Regional Information Office.

Superbird on the Job

Bob Smith, a local lawyer and part-time farmer, left his office early in the afternoon. His first love, farming, consumed much of his evenings and weekends. Combining two careers required him to manage his time carefully, and to use timesaving methods whenever possible.

Upon arriving home, he went immediately to the den and switched on his home computer, which was attached to a small black box that had an antenna protruding from it. He spoke directly to the computer and asked to be connected to Superbird, a "poor man's satellite," parked approximately 20 miles above the farming area.

Superbird did not look like the satellites of the 80's. It had large

winglike structures that served to stabilize it in the thin atmosphere and to gather solar power for the motor that kept it in the same place above the earth. The solar cells also powered the radiometer and lens systems that measured the reflected sunlight and other natural energy that came from the farms below. Superbird was a cooperative effort among farmers in the area; each had contributed towards the cost according to his farm size.

The computer responded instantaneously, making the connection. Bob asked to see a picture of the field in the southwest corner of his farm. Immediately a picture appeared on the TV screen on the wall in front of him. The view was of a lush green wheat field. Everything looked fine. Bob then asked the computer to show the same area, but in colors that would represent different temperatures. He knew healthy green wheat plants would all be nearly the same temperature.

The TV screen blinked and a beautiful picture appeared in shades of blue, red, and green. Bob looked closely at a large red spot that appeared near the middle of the wheat field. He sensed that something was wrong. The red color meant the spot was warmer than its surroundings. Some possible causes of the warm spot were lack of moisture, low soil nutrient supply, or insects feasting on the wheat or spreading a disease.

Bob told the computer to take certain parts of the light that was picked up by Superbird and combine them in a way that would tell him more about the warm spot on the field.

After trying several combinations, he decided the problem was a shortage of nitrogen in the soil. He asked the computer to predict what the yield would be if he did, and did not, add the suggested amount of nitrogen. He then told the computer the current projected market price for wheat and the price of the nitrogen and asked for an economic analysis, to see if it would pay him to add the fertilizer with the next irrigation.

Bob proceeded to survey his farm field-by-field, making decisions on how to manage each of them. Science fiction? No—not really. Are people doing this now? No, not yet, but much of the technology is here and such scenes could become commonplace.

Computers that listen and talk are for sale everywhere, but

scientists still have a lot of work to do before all the ways of using the reflected light and naturally emitted energy from earth can be put together to tell us if what Superbird sees is caused by insects, lack of nutrients, water, or whatever.

Also, the "poor man's satellite," a brainchild of several brilliant NASA engineers, is still a dream. But it will be built, and when it is, it will use the principles learned from the Gossamer Albatross, the lightweight airplane that was pedaled across the English Channel by a man.

When the entire system is finally in operation, small and large farmers will share equally in its use. It will be available on call, to give information on your farm—just by asking for it! Superbird, by taking a far out look at your farm, will be your own personal agricultural consultant.

By Ray D. Jackson, Physicist, U.S. Water Conservation Laboratory, Agricultural Research Service, USDA, Phoenix, Ariz.

A Sexual Revolution

Cattle reproduction is rapidly moving from the pasture to the laboratory. Better understanding of the reproductive process has taken much of the chance out of breeding and given us genetically superior offspring—animals that produce more meat and milk.

Artificial insemination was the first giant step. Males that sire more productive offspring are identified and their semen collected. After the semen is properly diluted and frozen, it can be sent anywhere in the world. Some bulls have sired over 150,000 offspring through artificial insemination.

Scientists have been attempting for many years to separate the X (female producing) sperm from the Y (male producing) sperm in bull semen so that the sex of offspring can be planned. Successful methods have been developed for identifying the sex of an embryo based on antibodies to the male tissue, and optimists predict success in the ability to control the sex of future offspring.

The super female can now be made to produce more offspring and this procedure could become commonplace. When the female is treated with a "fertility" drug, she will produce more eggs than normal. The eggs can be fertilized inside the female or removed and fertilized in a test tube where "matings" can be planned for each individual egg.

If the eggs are fertilized inside the female, the resulting embryos can be left to develop into twins or triplets, or they can be collected

and transferred to other females called surrogate mothers. When surrogate mothers are not readily available, the embryos can be frozen to await transfer at a later time.

Even a single embryo can be made to produce more offspring—thousands, in fact. A single-cell fertilized egg divides into 2 cells which divide into 4 cells, 8 cells, and so on. At this very early stage of development, each cell in the embryo is exactly alike. This means that splitting a 4-cell embryo into four separate cells by microsurgery and transferring these cells to surrogate mothers could result in identical quadruplets.

The potential of this technology is tremendous. For example, a female on fertility drugs can easily produce eight embryos. If these embryos are separated at the 4-cell stage, each cell grown in culture to the 4-cell stage, and the process repeated 6 times, over 4,000 potential offspring would be produced. And they would be genetically identical!

But the potential for manipulating embryos doesn't end there. Cells from a 1- or 2-cell embryo could have their genetic component removed or destroyed. A nucleus from a body cell of an adult animal could then be inserted into the embryonic cell, resulting in an identical copy (clone) of the adult animal.

Variations of cloning could also involve replacing the original nucleus with the nuclei from just sperm or just eggs. The offspring would have two genetic fathers or two genetic mothers. It could be the equivalent of crossing a bull with himself or a cow with herself. And the latter would insure that all the offspring are female.

These are but a few of the techniques that are causing a revolution in reproduction.

By R.A. Bellows, Livestock and Range Research Station, Agricultural Research Service, USDA, Miles City, Mont.

Microbe Engineering

The results of recombinant DNA technology are upon us and will make important contributions in many areas, including aging, cancer, vaccines, and immunology.

A piece of DNA that codes for a particular chemical can now be inserted into the genetic material of bacteria or other microbes such as yeast, even animal cells grown in tissue cultures. These new or altered life forms are then multiplied into billions of cells that produce the chemical for which they have been engineered.

So far, several biological products are being produced in this

manner—including human and cattle growth hormone, insulin, and interferon. And research is underway to develop organisms that will produce proteins which can be used as vaccines against viral hepatitis, influenza and foot-and-mouth disease.

The most commonly used "factory" for manufacturing these products is the bacterium *E. coli*, which is one of the most studied organisms known to microbiologists. It is precisely this background of knowledge about the organism that allows scientists to remove a circle of DNA called a plasmid, cut it by using specific enzymes, and insert pieces of DNA from another organism into the splice. When the reconstructed plasmid is reinserted into the bacterium, it produces the protein product for which it was coded.

Another approach to genetic engineering is to chemically synthesize the pieces of DNA from the genetic code and insert the synthesized genes into a plasmid. This approach was used in part for producing insulin.

Genetic engineering offers many advantages over current methods of producing vaccines. One of the most important is safety.

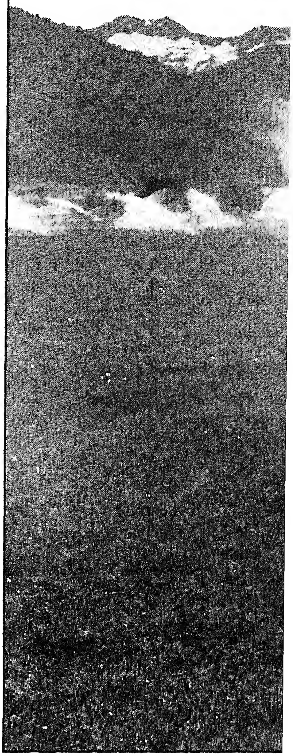
To produce a conventional vaccine, the disease organism must be grown in large numbers, then inactivated. Both procedures can be dangerous or difficult. For example, in countries where the incidence of foot-and-mouth disease is controlled by vaccinating cattle, recent outbreaks have been caused by escape of the virus from the vaccine-production laboratories or by inoculating animals with improperly inactivated vaccines. In addition to safety, genetically engineered vaccines likely will be many times cheaper than those from whole virus.

Much of the concern expressed several years ago by the public and some scientists over genetic engineering has subsided because more has been learned about the technique, and there have been no adverse effects from the work. The advantages which have already been achieved and the potential for developing basic knowledge as well as for producing other useful products bodes well for this new technology.

By Jerry J. Callis, Director, Plum Island Animal Disease Center, Agricultural Research Service, Greenport, Long Island, N.Y.

Water Wizardry

Water, water everywhere...Not so anymore. In fact, the energy crisis of the 1970's will take a back seat to the water crisis in the 1980's and 90's. But water problems are nothing new. Recent court battles over water resources in the West are reminiscent of the



GENE ALEXANDER

Agriculture is the Nation's largest single consumer of water. Irrigated agriculture produces 20 percent of the gross income received for farm products, but uses only 10 percent of U.S. cropland.

gunfights over water rights of a century ago, only the adversaries now file briefs instead of firing bullets.

Agriculture has been the single biggest user of water, with 10 percent of U.S. cropland now under irrigation. Irrigated crops account for 20 percent of gross income received for farm products, largely in fruits and vegetables. Experts predict that little additional water will become available, and agriculture will have to compete with industry and urban development for it.

The American farmer has always learned to cope with adversity and the problem of competition for available water will be no ex

ception. Farmers in the more arid Western States will switch tc crops that can be grown without irrigation or to new varieties th yield well with less irrigation.

Growers east of the Mississippi, where water is more plentifu may be supplying more of the fruits and vegetables now grown the West.

But geographic redistribution of crops will not be the only solution. Before our modern Farmer Brown turns on his irrigat system, he has several options for saving water made possible by advances in science and technology.

He may choose to plant some of the new drought-resistant va eties that plant breeders are now working to create. Varieties o corn, wheat, cotton, hay and other crops will, in the future, giv more yield per unit of water.

If he has a problem with runoff, he may decide to invest in tl fuel needed to reshape his land to hold more water on the crops. can also convert his older irrigation system to more efficient equipment such as the trickle system.

Water sensing devices that can be buried in the soil will help c modern Farmer Brown to know when he needs to add water to supplement natural rainfall. And his extension agent can advis him at what stage in his crops' development he should irrigate get the greatest yield from each unit of water applied.

He can enter this information into his home computer, along with available weather data, soil moisture readings and crop cor tion information to help him decide when to add water and hov much to add.

Irrigation will continue to be a big factor in providing the American consumer with high quality fruits, vegetables and ot crops. But it will be used more wisely and the geographic distrib tion of crop types is bound to change.

By Carl W. Carlson, Soil and Water Scientist, Agricultural Research Service, US (retired), Ruckersville, Va.

The Fix Is In

Agricultural legumes like soybeans, peas, cowpeas, alfalfas a clovers not only supply their own nitrogen, they help to repleni the soil for crops that require nitrogen fertilizer, such as corn, wheat, barley, rice, sorghum, sugar beets and many others.

The market value of nitrogen produced by agricultural legum in the United States is nearly $5 billion per year. However, crop that can't produce their own nitrogen still depend heavily on co

mercial fertilizers which require large inputs of natural gas and electricity to manufacture. And, as every homeowner knows, it takes fertilizer plus "April showers" to make lawns green up and stay green and healthy throughout the growing season. But the cost of manufacturing these fertilizers is ever increasing.

Since nature has given us air that is 80 percent nitrogen and microbes that can transform (fix) this gaseous nitrogen into the compounds that plants need, why not improve on nature? Scientists are doing just that.

These unique microbes have an enzyme called nitrogenase that enables them to be little nitrogen factories. Some live freely in the soil while others live in nodules formed on the roots of legumes. Their ability to fix atmospheric nitrogen also benefits leguminous and nonleguminous trees and shrubs.

Farmers and gardeners can now go to the seed store or garden center for legume seeds and buy their nitrogen fertilizer in the form of a small packet of microbes which they can apply on the seed or plant to form nodules.

What improvements or new technology might be expected in the future? Scientists are transferring desirable traits from microbe to microbe to develop new breeds that are more efficient nitrogen factories, more resistant to the hostility of their soil environment, and more specific for a selected plant that has been bred to better use the nitrogen from the nodule.

The farmer will be able to buy a soybean variety and a microbe custom-bred for one another as well as for a particular field so there will be no interference from microorganisms left in the field from other years. He might also request microbes that don't stay in the soil more than one cropping season, so that if he changes varieties of soybeans he can custom order another nodulating microbe that will be the most efficient the following year.

Once scientists understand all the mechanisms that make the root-nodule nitrogen-fixing system work, the farmer may supply nitrogen to his corn and wheat the same way he does for legumes.

Not all crops are likely to become independent of commercial nitrogen fertilizer; in many cases both systems complement one another in total crop production. But commercial nitrogen fertilizer may be manufactured some day by using the nitrogenase system of microbes to fix atmospheric nitrogen into the compounds plants can use. The process will use less energy and, because of this, the product will be cheaper.

By Deane F. Weber, Microbiologist, Agricultural Research Service.

Designer Genes

Green plants function as solar energy machines—converting sunlight into food, fiber, oil, and biomass (energy) for a world population of 4 billion people. Crop plants are the heart of a vast agricultural system that deserves recognition as one of our most precious natural resources. Recent discoveries in gene splicing raise the possibility that any gene from any source can be engineered into plants.

Traditionally, plant breeders have combined the desirable genes or traits from two different parents into one individual progeny through breeding. However, breeding can occur only between closely related plants. Corn, for example, will not cross with wheat.

Genetic engineering techniques may ultimately permit taking genes from any plant species and inserting them into any other plant.

For example, several genes that each confer resistance to a different disease-causing fungus could be isolated from several plant species that each naturally possess resistance to one of the fungi. These several genes could then be attached together in a test tube, multiplied in the bacterium *E. coli* and put into a crop plant such as corn. The corn would then possess multiple resistance to those several disease fungi.

Another example involves the ability of certain crop plants such as soybeans and clovers to enter into a symbiotic association with certain bacteria. These bacteria take nitrogen from the air and "fix" it into a chemical form that plants use for making protein. The need for applying expensive nitrogen fertilizer to these crops is largely eliminated.

Genetic engineering techniques may enable scientists to isolate from soybeans the genes that permit this association to occur. These genes may then be moved into such crops as corn or wheat, crops that now consume a great deal of fertilizer nitrogen. Their engineered ability to associate with nitrogen-fixing bacteria would considerably reduce the need for fertilizer nitrogen.

Genes now being isolated from plants include traits for disease resistance, herbicide tolerance, drought tolerance, photosynthesis, fertilizer use efficiency and symbiotic nitrogen fixation. Special pieces of DNA called vectors are used to carry genes from one plant to another.

At least three different vectors for plants are now being

studied—all with a note of optimism. Once the genes are "loaded" in their vectors, they then must be delivered to suitable target cells. One approach is to use isolated plant cells stripped of their thick outer wall; these cells will develop into mature plants harboring the new trait. Difficulty with that delivery step is a critical bottleneck at this time.

When can this exciting challenge be achieved? A great deal of venture capital is pouring into the field. Success is based on rapid advances in isolation and cloning of plant genes, development of plant vectors, and new strategies for plant cell culture. The first products should be available in the 1980's.

By R.C. Valentine, Professor, Plant Growth Laboratory, University of California, Davis, and L.D. Owens, Plant Physiologist, Cell Culture & Nitrogen Fixation Laboratory, Agricultural Research Service, USDA, Beltsville, Md.

Living Insecticides

What would be your reaction if you were told that living germs could be used to effectively control insect pests in your home, garden, and on your farm? Astonished! Don't be! Insecticides formulated from living microorganisms rather than chemicals are now on the market, and more will be available within the next decade. Future living products will also be used to control weeds, tapeworms, nematodes, ticks and other parasites and diseases of man, domestic animals, and plants.

Insect pests, like all living things, are susceptible to diseases caused by bacteria, fungi, protozoa, and viruses. These microorganisms are not new; they are already present in the environment and often naturally control populations of insects which injure man and cause extensive damage to food and fiber crops. They also have been naturally screened over millions of years to fit the environment. Scientists are now finding how to effectively use them for mankind's benefit.

Commercial formulations of these microbes are called Living Insecticides. There are more than 1,500 of these natural, safe, biodegradable microorganisms that might be formulated into living insecticides, and the number does not stop with those already known. New microbes are being discovered each year. In fact, the number of candidate microbes could double in the next decade.

The potential impact of substituting microbial insecticides for chemical insecticides can be substantial. In the United States alone, use of a living viral insecticide to control bollworms and

One of the living insecticides that researchers are studying is a fungus that successfully attacks the larvae of soybean podworm, green clover worm, cabbage looper, and soybean looper.

budworms on cotton, a living fungus against the citrus rust mite, a bacterium against cabbage worms, and a living protozoan against grasshoppers could replace about 20 to 30 million pounds of chemical insecticides annually.

If formulated from micro-organisms, are these living insecticides safe? There never has been a death in humans due to either the experimental or commercial handling of over 100 different kinds of microbes which attack insects.

Some remarkable achievements in the development and use of living microbial insecticides have occurred within the past decade

Basic and applied research in this area, practically nonexistent after World War II, is now a formalized science. A new industry has blossomed to produce and commercialize safe and effective microbial insecticides which are now being mass produced and effectively used by growers and home gardeners to control damaging insects such as caterpillars, grubs, flies, mosquitoes, mites, weevils and even hard to kill grasshoppers that are pests of vegetables, fruits, fibers, and forests. Yes, you will be using living, environmentally safe pesticides.

By Carlo Ignoffo, Biological Control of Insects Research Laboratory, Agricultural Research Service, USDA, Columbia, Mo.

Pinpointing Disease

Poultry producers lose $200 million each year to a disease called coccidiosis because the birds fail to grow as they should. They spend another $90 million on medicine to control this disease. But an effective vaccine against coccidiosis would eliminate these extra costs and reduce the price of poultry for the American consumer.

Vaccines in general could drastically reduce the billions of dollars spent each year for medication to control a menagerie of human and animal diseases. But even when good vaccines are available they are of no value to some people and animals because their bodies can't produce antibodies—those secret police which stand ready to capture and subdue a foreign chemical or organism called an antigen. Instead, antibodies against these infectious agents could be administered if they were available.

Where there is no effective vaccine—which is the case for most types of human and animal infections—medication may be the only way to restore health. But what is the cause of the infection? Which antibody or drug would be most effective?

To solve all these problems one would need a whole bag of magic tricks, right? Maybe not. The answer may lie in hybridomas—cells which produce one, and only one, very specific antibody.

Hybridomas are made in the laboratory by fusing an antibody-producing cell from a mouse's spleen with a cell from a mouse tumor, called a myeloma, which will multiply rapidly outside the mouse's body in tissue culture, but will not grow in any other species of animal. Although the spleen manufactures the whole range of antibodies, individual spleen cells produce only one, specific antibody. Thus, in a hybridoma, the spleen cell provides the design of the product while the tumor cell provides for

mass production of the product. The product is called a monoclonal antibody.

How will these antibodies help produce new vaccines, improve diagnosis, and fight disease, including cancer? The answer is in their purity.

The organism that causes coccidiosis consists of hundreds of antigens, each of which stimulates a specific antibody. And multiple antigens are common in most disease organisms.

When all of these antibodies, combined with thousands of antibodies to other organisms, are swimming around in the chicken's blood, it is very difficult to study the antigens which could be used to develop a vaccine. But hybridomas can produce a pure antibody for each antigen on the coccidia organism. These antibodies will hook up with their specific antigen, enabling scientists to isolate and study them.

The same principle makes monoclonal antibodies extremely valuable for diagnosing disease agents. When a disease agent is isolated from a sick person or animal, it is often identified by mixing it with antibodies against several germs to see which antibody it reacts with. These antibodies are now prepared in animals, but because the preparations contain antibodies to other germs the animal has contacted in nature, the tests are not always accurate. Monoclonal antibodies may not only pinpoint the cause of disease, they could also be used to measure the degree of immunity that the person or animal has developed.

They can also be given to humans or animals to help fight infection on a temporary basis. Since they are pure they would not produce side effects.

Monoclonal antibodies are only six years old and fast becoming child prodigies.

By M.D. Ruff and H.D. Danforth, Poultry Parasitic Diseases Laboratory, Agricultural Research Service (ARS), Beltsville, Md.; and C.H. Campbell, Plum Island Animal Disease Center, ARS, Greenport, Long Island, N.Y.

Catfish Alley

Fish is the only class of foods that is still gathered from the wild. Because they come from sources over which man has little or no control, their supply, quality and price are quite variable. In addition, we presently import 66 percent of our seafood.

But all this is changing. American farmers are now producing fish under managed conditions just as they have produced meat,

Catfish production on U.S. farms rose from 20 to 125 million pounds in the past decade. Fish are among the most efficient feed converters, gaining a pound of weight for every 1½ pounds of feed.

milk, eggs, fruit and grain for centuries. It's called aquaculture.

From 1970 through 1980, the harvesting of channel catfish increased from 20 million pounds per year to 125 million pounds. The channel catfish has the greatest potential for commercial culture because it can be grown in all parts of the United States, and it reproduces and grows easily under managed conditions. It has few bones, white meat and a mild flavor—all of which help make it attractive to the consumer.

A well managed catfish farm can yield about 110,000 pounds of fish per man-year of labor. Yields of 5,000 pounds per acre are commonly harvested from earthen ponds which average about 10 acres in size.

It takes 1½ years for a channel catfish to grow to its market size of 1 pound. During its first summer, the fish grows to about 5 inches in length. In its second summer it is fattened up before it goes to market. The fish are harvested and taken live to a processing plant where they are slaughtered, frozen or packed in ice, and distributed to retail markets.

Research has provided us with information on genetics, disease, nutrition and economics which has allowed for the farming of several species of food fish. In future years, trout and salmon will be cultivated more intensively and some of the popular marine food fishes will join the ranks of farmed fish, helping to reduce our imports while providing the American consumer with a high protein diet at a reasonable price. Shrimp, crayfish and oysters will be reared from egg to adult rather than left to endure the cyclical ups and downs of Mother Nature.

Fish are highly efficient in converting feed into the proteins humans need. They gain 1 pound of body weight for every 1½ pounds of feed. They are more efficient in using food calories for growth than warmblooded animals. They are more efficient than beef or pork and about equal to chickens in converting food protein into body protein.

It takes about the same amount of fossil energy (petroleum and coal) to produce channel catfish as it takes to produce poultry, which is lower than that needed to raise other land animals.

Through continued research, yields will increase, production costs will decrease, new culture techniques will emerge and new fish species will be harvested on fish farms instead of being gathered in the wild.

By Richard T. Lovell, Department of Fisheries and Applied Aquacultures, Auburn University, Auburn, Ala.

The Land and Water Squeeze on Our Food

By William Whyte

"The first man to fence in a piece of land, saying, This is mine,' and who found people simple enough to believe him, was the real founder to civil society."
Jean-Jacques Rousseau, 1712-1778.

"The first farmer was the first man and all historic nobility rests on possession and use of land."
Ralph Waldo Emerson, 1803-1882.

These quotes may be in opposition on the legality of the institution of private property, yet they share a common thought: How well land is used is important to social order and influences society for good or ill.

Humankind is still experimenting with basic philosophies on the ownership and use of land. Historically, the concept of land ownership has stirred debate concerning its impact upon the distribution of wealth in a society.

Today we recognize land as a national resource, whose ownership carries both rights and responsibilities. The responsibilities are not yet as well defined legally as the rights, and therein lies the rub. Will we have adequate land to produce the food and fiber we need in the 21st century if land development continues unabated?

Suburban housing, energy, transportation and other large land users are bidding for agricultural land at a level that often excludes agricultural interests from holding on to it. Land moved out of agriculture is rarely returned to crop production. It is frequently our best farm land. Land brought into agriculture is usually more difficult and costly to farm, and less productive than the acreage being lost.

Our Cropland Base

Early in 1981 the five-year National Agricultural Lands Study was completed by the Federal Government. It offers us the most useful data to date with which to review cropland resources and to study scenarios of what could happen to food supplies as we enter the next century.

Today the United States has about 540 million acres of what we call ou[r] cropland base. It is land with a medium to high potential for produc[t]ing crops. To break it down one step[,] 413 million acres of this land are readily available as cropland, although not all of it is in crops at present. The remaining 127 million acres are potential cropland, most of it in pasture and rangeland with about a third in forest and other lan[d] use. This cropland base constitutes the heart of our agricultural land resources.

Beyond this acreage we have som[e] 268 million acres of land with a low potential for cultivated crops.

All this land is part of a much larger land category called our agricultural land base. Consisting of 1,361 million acres, it contains not only all our cropland but all our rangeland, pastureland, and forest land.

Land moved out of agriculture for housing, roads, and highways usually is lost to agriculture forever. Unfortunately that land is frequently our best farmland.

Annually about 3 million acres are removed for other uses from the agricultural and base. A third of these acres are prime farmland, land with the highest potential for producing crops, which probably is lost to agriculture forever. While the nonagricultural land usually is taken for important needs, many of the needs could be met without eating so deeply into these best of agricultural lands.

Meanwhile, the monetary and environmental costs of bringing new land into crop production are much higher than they used to be. The problem, if left unchecked, will eventually become critical and—at that point—beyond remedy. The "Catch-22" is when people have enough food and can afford it, the national constituency for preserving agricultura lands becomes small indeed.

Farmer Needs

American farmers will have to cultivate about 50 percent more croplanc by the year 2000 than they do now even if productivity continues to ris about 1 percent a year. Increased demands of domestic, export and fuel crop markets could reach 85 percen over current levels and force into production all of our agricultural land base by that time.

Major adjustments in the agricultural system would include a large movement of forage land into crop production. Livestock grazing woulc probably be substantially reduced. Confinement feeding of beef would b more commonplace, with accompan

ing increases in the real costs of meat.

Project this to the year 2030 and we easily could be 112 million acres short of cropland, having lost 50 million acres from our 1980 agricultural land base to nonagricultural uses.

This is what Americans face today, an entirely different situation with their agricultural lands than they have in the past. Until the 1970's, when we increased our cropland by 60 million acres to meet increased demand, the amount of land under cultivation in the United States had not changed significantly. From 1915 to 1955, in fact, it remained at close to 345 million acres. By 1972 it had even decreased to 289 million. It has since expanded to 353 million acres in 1980 and will continue to grow with the demand for products in the years ahead.

Some setbacks in agricultural productivity occurred in the 1970's that have sped up this rising need for land in crops. Costs of fuels and fertilizer as well as other energy inputs escalated rapidly. Land available for crops was less fertile than in the past. Water supplies tightened and growth rates on irrigated lands were not always maintained. Erosion and salinization made significant inroads into soil fertility. The population, which had been migrating from rural areas to urban areas, began a reverse flow to the countryside.

Transition Period

Clearly we are in a transition period between the surpluses of the past and a time when our agricultural land and other resources will become fully used.

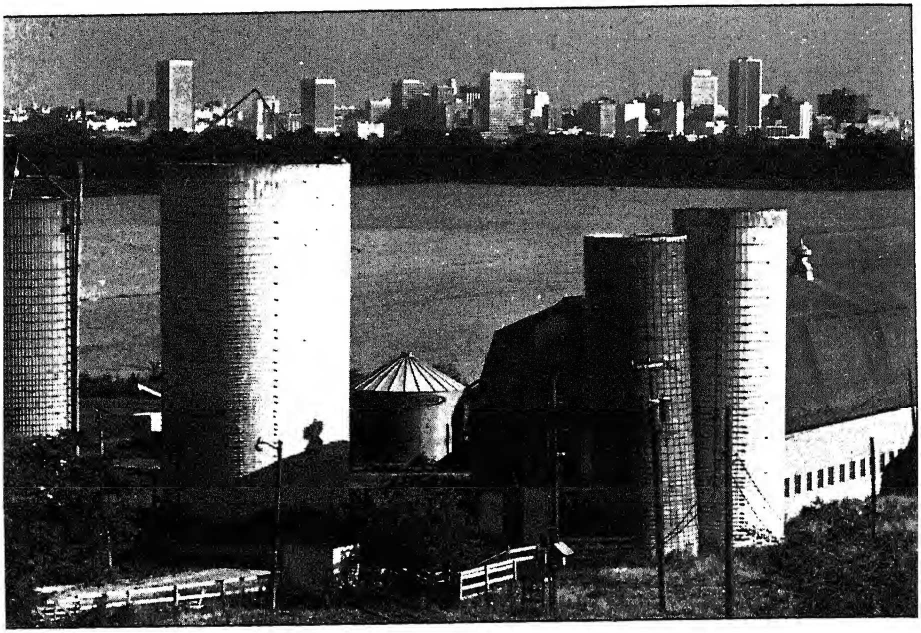
Secretary of Agriculture John R. Block expressed it this way, "All of the statistics, legislation, and studies mean nothing without a basic understanding that in the next 20 years we cannot meet a 60 to 85 percent increase in demand for U.S. agricultural products while urbanizing 3 million acres of productive land each year and maintaining current low productivity rates."

Acreage, as he notes, is but one dimension of the situation. Land must be considered in terms of crop yields, access to water and its vulnerability to erosion if we are to examine the bottom line, which is productivity.

Agricultural land having the best of these characteristics is prime farm land. It is level, free of stones and obstructions, served by roads, electricity and other services necessary to growing and marketing crops. It is in relatively large tracts. It is physically and chemically right for producing food, feed, forage, fiber and oilseed crops and has the growing season and moisture supply needed to economically produce high yields of crops when properly managed. And it is the least expensive land to farm because it is so good.

The Nation has about 345 million acres of prime farmland. All but about 15 million acres of it is in cropland. It is the most vulnerable land for development by nonfarm users. Development in our 100 best agricultural counties is taking place at twice the rate it is nationally.

This is largely because many population centers are in the heart of prime farm areas—Chicago, for instance. Not only does suburban development consume the prime farmland directly, but for every acre actually used another acre is



Farming vs. urbanization. Concerned about the rapid disappearance of farmland, Secretary of Agriculture Block said we cannot continue to meet increased demands for U.S. agricultural products while urbanizing 3 million acres of productive land each year.

isolated from ever being used as cropland because development leapfrogs into the countryside.

Stop Urban Expansion?

A 1980 Congressional report titled, "Compact Cities: Energy Saving Strategies for the Eighties," suggests stopping or reducing urban expansion to protect farmland.

It points out that the pattern of suburban growth comes more from habit than from necessity. It requires the constant development and duplication of public facilities such as schools, streets, and lighting as well as services. Meanwhile, existing facilities deteriorate and a quarter of the privately owned land in central cities lies vacant.

The conclusion is that the Nation could double its current population and provide housing for everyone without expanding existing municipal boundaries.

While this makes sense, it is also evident that the compact cities approach would not be a quick turnaround for existing trends. But it is the direction in which we should be moving.

The urban renewal in many of ou cities is a promising beginning. How ever, over the last decade the Natio has witnessed a migration from urban to rural areas. Forty percent the housing built during that perio was on rural land. Almost 12 millio new housing units are likely to be added in nonmetropolitan areas by 1995.

By the mid-1970's, only 684 counties in the Nation received 20 percent or more of their income farming. As recently as 1950 that figure was 2,016 counties.

Suburban growth will continue throughout this century while sunbelt cities increase in population 12 percent and frostbelt cities decline in population by 4 percent. Developmental pressures on agricultural lands may actually intensify in the last few years of the 1980's because the disparity between demand and availability will be greatest during this period.

Energy Impact

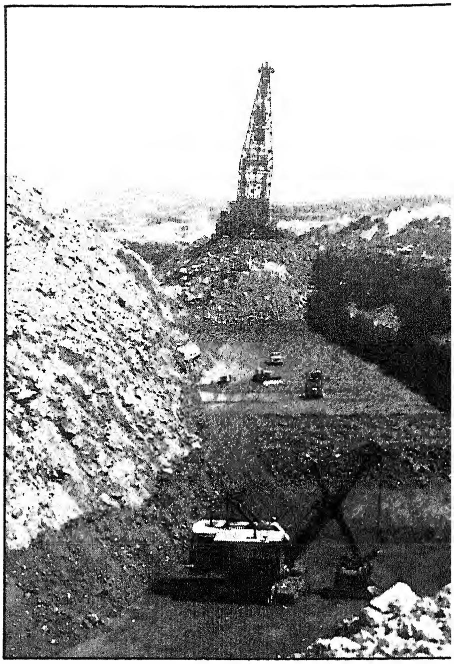
The Nation's expanding search for energy is expected to require increasing amounts of land, much of it farmland. Coal companies plan to mine another 312,000 acres by 1985. The fact that this coal-mined land must be restored to its former state gives little compensation to agriculture. Reclaiming mined land for farming is expensive and crop yields are often substantially below what they originally were.

Land stripmined for minerals other than coal remains unreclaimed, as laws currently do not protect it.

Each new power plant requires 2,000 acres or more plus large areas for support facilities. Electrical transmission rights-of-way are expected to require up to 3 million more acres of land before the year 2000. Much of that land, of course, will still be farmed, but presents special problems for farmers.

The greatest threat to agricultural productivity from energy development lies in its potentially large water requirements, much of which would be diverted from agricultural uses. How serious this competition will become can be assessed when the direction and extent of energy development in the West emerges. One alternative may help in the Southwest, where some water for energy development can be pumped from deeper aquifers than are economically available to agriculture.

Agriculture itself may take land from food and fiber crops to produce energy in the form of fuel crops such as oil- and alcohol-producing crops. How much will depend on technological advancements in producing oil fuels and engines to burn them cleanly, and economic incentives and



N.P. McKINSTRY

The demand for energy will take more crop and range land out of production since coal companies plan to mine another 312,000 acres by 1985. Even if land is reclaimed, crop yields are often much lower.

ome technological improvements in he production of alcohol for use in ;asohol. While this land would re- nain agricultural, it could be dif- 'icult to recapture for production ›f food.

Farmers Who Give Up

Perhaps the most immediate impact hat conversion of land to nonag- ·icultural uses has is on the farmers .hemselves. A pattern of behavior ong observed in farming areas as .hey are overtaken by population ınd competing land uses has ɔeen labeled the "Impermanence Syndrome" by sociologists.

Farmers become discouraged by the changes around them. They begin to see development of their land as inevitable. They understandably stop putting money into either keeping up their buildings and equipment or applying conservation practices to the land. Finally, they mine the land, getting as much out of its remaining fertility as they can with minimum input.

At this point they may have no choice as suppliers and services upon which they depend may already have closed up or moved on. These farmers often sell to developers and get out of farming.

The pattern is common in the Northeast where people increasingly depend on food trucked in from far away. The surrender of farmers to advancing urbanization is of special concern there, as consumers begin to see the value of retaining a supply of fresh farm foods in their counties or at least in their States. Some endorse petitions at farm roadside stands and come to the aid of farmers in hearings before county officials to help keep local farms from vanishing. This is in marked contrast to the conflicts that can arise between suburbanites and farm neighbors because of noise, odors, damage t crops and other mutual irritatior

The heavily developed but fert Northeastern States contain 25 percent of the Nation's populatio and only 4 percent of its croplan

This area has slightly over 4 percent of the country's high anc medium potential cropland. In te of prime farmland it has 14 mill acres, surprisingly more than eil the eight Mountain States or fiv Pacific States.

Danger Areas

The National Agricultural Land Study lists many of the Northeas States among those in danger of ing almost all their farmland by year 2000. It indicates that Flor New Hampshire and Rhode Isla could lose most of their remaini farmland in the next 20 years— if the current annual losses go c Likewise, West Virginia could lo percent during that time; Conne icut, 70 percent; Massachusetts, percent; New Mexico, 50 percen Maryland, 44 percent; Vermont, 43 percent; and Utah, 35 percen

These States could be left tota dependent on the transportatior dustry for foodstuffs, which wou bring sharp rises in food prices. has led State and local leaders t stitute measures to save farmla or slow its conversion.

Nationwide, less than 20 mill acres of existing or potential cr land are protected under compr sive State or local programs. An the legal mechanisms now bein

lorida's farmland — its citrus groves, vegetable fields, and pastures —
re disappearing at such a fast rate that there may be little left by
le year 2000. Other States that could lose most of their remaining
ırmland in the next 20 years are New Hampshire and Rhode Island.

ımployed to protect farmers from levelopment are:

Agricultural zoning, which retricts uses to agricultural and reated uses. Critics say it can be easily urned around when pressure for ıonagricultural uses grows in an .rea.

Purchase of development rights, a uccessful technique in some areas of he country. Here the jurisdiction or non-profit organization buys deelopment rights on farmland, which educes the cost of that land proporionately. This makes it easier for a ırmer's relatives or others who want o continue the farm to buy it. It enbles a farmer to get money without ıaving to sell out, and assures that he farmland will be preserved.

This process has proven useful in Massachusetts, where the Massachusetts Farm and Conservation Lands Trust, a nonprofit private trust, was set up to purchase development rights on farmland. According to State Commissioner of Agriculture Frederic Winthrop, Jr., the trust can act more quickly and sometimes in ways in which the State cannot act.

Critics of the purchase of development rights say it is too costly to work in major agricultural areas such as Iowa and California. It may be best suited in areas where farms are comparatively small.

Comprehensive planning can provide some protection for farmland, or at least reserve it until a more permanent solution can be found. It is not legally binding in and of itself.

Agricultural districting is used to identify specific areas where long term farming operations are located. These may be areas where farmers only pay taxes for the agricultural value of the land, and are otherwise relatively free of land development pressures.

Transfer of development rights is applied where a developer has purchased rights in a designated preservation area. Those rights can be transferred to a designated development area where the facility that the developer was planning can be constructed.

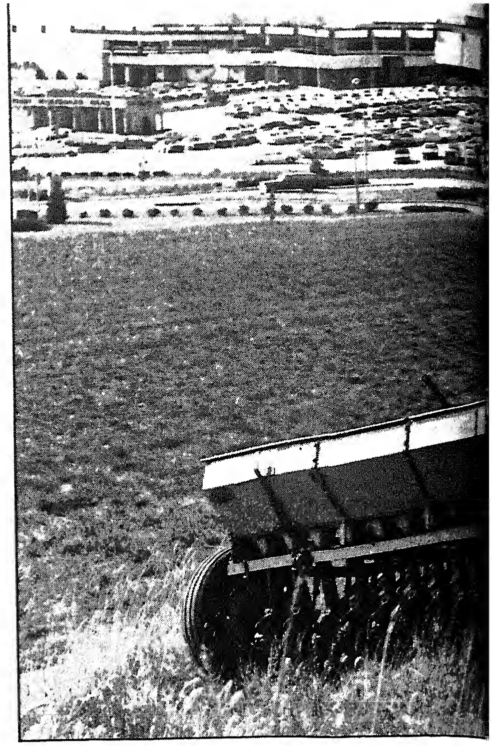
Differential assessment of farmland is scaling the property tax to farm use instead of the land's market value. It relieves the farmer of the high tax burden caused by rising land values.

A *development permit system* requires that a developer obtain an additional permit from a special State or regional agency in addition to those normally required.

Right to farm legislation protects farmers from local ordinances that frequently accompany suburban encroachment, unless the farming practices endanger public health or safety.

Basic to protecting farmland, of course, is reforming inheritance tax laws so that land need not be sold to pay taxes whenever an estate is transferred.

While the methods employed have obvious limitations, they are encouraging in their diversity. If farmland is to be saved, much of it will have to be at the discretion of local citizens who know the productive capabilities of the agricultural lands in their area. The danger, if there is one, is that local people may not see



the loss of their agricultural land as that important to the Nation, and opt for continued rapid development.

Regional Concerns

Having noted the special importance of preserving farmland in the Northeastern United States, here are some of the concerns of other regions:

The *South* has sizable reserves of land suitable for agriculture, even in comparison to land now being cultivated there. Other major users, such as timber producers, have their eye on much of the same potential cropland. Demands for timber are expected to increase 40 percent in the next 20 years. Much of this demand will have to be met by increased production in the Southeast.

In the *North Central Region,* more


CHARLES EBERSPACHER

If farmland is to be saved from non-agricultural development, it will have to be at the discretion of local people. Nevertheless, loss of productive cropland is not generally considered by most people to be a critical problem yet.

than other regions, urban growth consumes the most productive acres because its many towns and cities are in the midst of prime farmland. Extensive coal reserves in States like Illinois are another potential threat to these prime farmlands—even though the Nation has an estimated 300-year supply of coal not underlying prime farmland.

The *Western Region* depends heavily on irrigation, and its future productivity is most threatened by the continued depletion of its aquifers, in large measure by agriculture itself.

Water is as important as land to our future agricultural productivity. Agriculture uses about 83 percent of the Nation's water supply—almost all of this for irrigation, especially in the West. Like other users, agriculture's demand for water increases every year.

Surface water from streams, rivers, lakes, swamps and manmade reservoirs is used and reused by agriculture as it is available.

Plains Problems

A quarter of all the water used in the United States is ground water from vast underground aquifers, and agriculture uses half of it. Our reserves of this water, once thought inexhaustible, are estimated to be the equivalent of 35 years of surface water runoff.

In some agricultural areas in the High Plains, groundwater levels are dropping 10 feet a year. Recharge is slow, perhaps 3 inches a year. Without irrigation water, much more of

the Great Plains would have to revert to low yielding dryland farming. Extensive wind erosion could occur in areas that run out of accessible water for agricultural land.

Some of our most versatile farmland is in areas where specialty crops are grown. These are also high value crops and contribute greatly to an area's economy. The nine-county areas surrounding San Francisco Bay, for instance, produce more foodstuffs than 13 States. Yet even in this vitally important agricultural area, about 19,000 acres are converted annually—mostly to residential building sites.

Losing this quality farmland, which can never be replaced, clearly indicates that conversion of farmland is not generally perceived as a critical problem yet. A dramatic sign that cropland is, indeed, in short supply may be required to spark broad public support, and make protection of agricultural lands a National issue.

Scarcity and high prices set off national alarm over energy. The National Agricultural Lands Study sounds a much softer warning, but hopefully one that intelligent people can understand and act on.

A Capital Trap

Quite apart from the competition for land, economic pressures in the agricultural system itself can force farmers out of business and farmland out of production.

Farmers are entering a changing economic climate in which they have to compete extra hard for capital to pay for the costly inputs required to operate a farm these days. Many, especially small farmers, are unable to compete with corporations and State and local governments for borrowed funds.

For years farmers used their rapidly appreciating land values to provide them with an almost unending source of credit, even when production returns were not keeping pace. Now they risk being caught in the equity-financing trap in periods of high interest rates. The high rates can eventually eat away at the equity the farmer has in land.

Since agriculture will continue to be highly capital-intensive, farmers are expected to continue to increase their debt financing in the decade ahead.

Helping them in this financial squeeze is the expansion of agricultural markets at home but especially abroad. As agriculture's resources become fully used to meet this demand, farmers are likely to receive considerably higher real profits from their commodities.

William Whyte is a staff member of the Special Programs Center in the Office of Governmental and Public Affairs.

Savaging Our Soil, Sustainer of Food and Life

By Lloyd E. Wright

It can take up to 1,000 years for 1 inch of topsoil to form under natural conditions. But this inch of topsoil may be lost in only 4 years through erosion in many parts of the country. In addition to erosion, millions of acres of the Nation's lands are being degraded by poor farming practices, irrigation-related salts, heavy metals, acid rain, floods, and toxic chemicals. Besides degrading the soil, all these forces are polluting our lakes and waterways with sediment, heavy metals, chemicals, and pesticides.

Soil usually is regarded as the outer 6 feet of the earth's crust, although it may be as shallow as 1 inch or as deep as 40 feet. The top 10 to 24 inches of soil (where most of the organic materials are formed) is called topsoil.

Soil quality is the soil's capacity to support and provide nutrients and water to a given plant under a given set of management conditions. Certain soil characteristics indicative of quality can be measured, but soil quality per se is a value judgment.

Soil consists of minerals, organic matter (dead plant and animal remains), air, and water. Soil texture (the relative proportions of various sizes of soil particles), pore space, and the amount of organic matter the soil contains affect movement of water in the soil and make nutrients and moisture available to plants growing in it.

Organic matter in soil is determined by the amounts of dead animal and plant remains and the effects of climate on their decomposition. When very large amounts of plant and animal remains collect, the amount of organic matter is high and increasing each year. Fields that are being cropped and have high erosion rates contain less organic matter, and the amount may be decreasing.

A number of other factors affect the amount of food that can be produced from a given acre of land—type of crop, quality of seed, amount and type of fertilizer, pesticides, equipment used, tillage methods, weather, and farmer skills. One of the most important factors is soil productivity. In the Nation's orchards, croplands, rangelands, and forests it relates to ability of the soil to hold and provide water and nutrients to plants.

Farming practices, high levels of erosion (detachment and removal of soil particles), improvements in structure caused by normal weathering, and pollution can singly and in combination change our soil productivity over time.

Masked by Technology

During the past 50 years, most of the negative effects of erosion, compaction, and pollution on soil productivity have been masked by improved technology. The technological improvements range from hybrid seeds, improved pesticides, and specialized

Uncontrolled runoff of rain has washed tons of soil from this Oregon field. Erosion is the most serious threat to U.S. soil productivity.

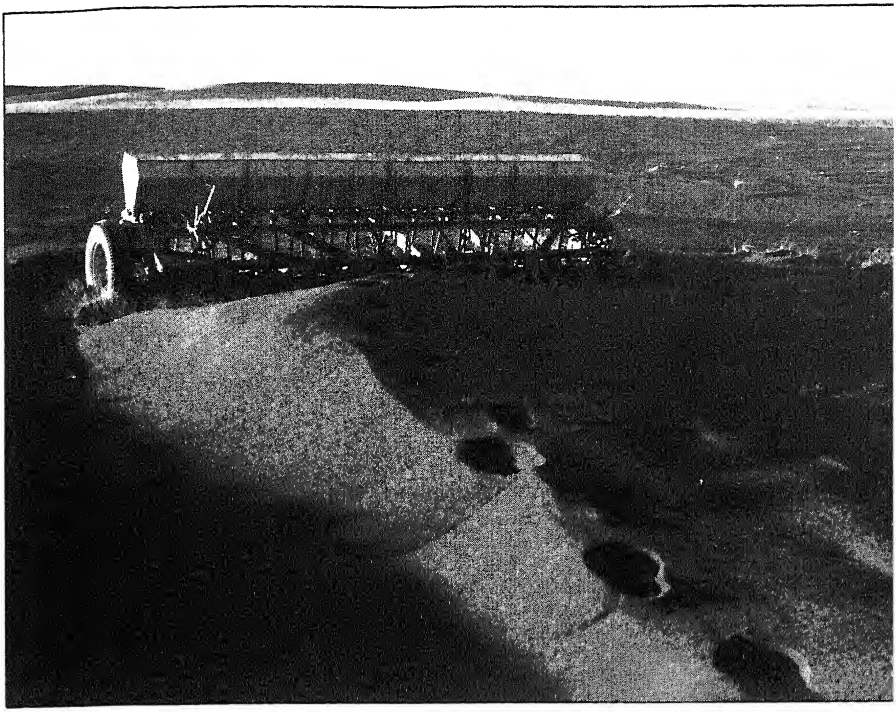
equipment to improved management of fertilizer application, tillage practices, plant population, and water.

Most of the increases in agricultural production in the last 50 years can be attributed to these technological advances. These increases have made it difficult for the public to understand the need for reducing the rate of soil degradation.

Many scientists believe increased use of fertilizers and pesticides and other new technology has slowly damaged soils to the point where increased application of advanced technology will no longer hide the negative effects. In their opinions, the effects of soil quality degradation may be irreversible.

Erosion is by far the most serious threat to soil productivity. This detachment, movement, and w away of land surface by movin ter, wind, ice, or geological age Cropland is affected mainly by and wind erosion.

Water erosion can be classifi four major types: *sheet erosion* ally undetectable by the huma where thin, uniform layers of s removed from the land surface *erosion*, where small channels into the land surface a few inc deep; *gully erosion*, where dee narrow channels form and soil moved to depths ranging from foot to 100 feet; and *stream ba sion*, where the force of water fined waterways removes soil the banks of the waterway or



GILBERT BIERWAGEN

Wind erosion is a major problem in low rainfall areas of the West. The most serious damage occurs in the Great Plains.

The two types of water erosion that affect productivity most are sheet and rill.

Wind erosion is a major problem in low rainfall areas with high wind velocities. The most serious wind erosion occurs in the Great Plains States.

Geological forces, such as the eruption of Mount St. Helens, also produce erosion. Dramatic though instances of this may be, geological erosion is not a major threat to soil productivity. That is fortunate since man cannot control it. Water and wind erosion, on the other hand, are largely controllable.

Unacceptable Erosion

The U.S. Department of Agriculture (USDA) estimates that more than a third of the cropland in the Nation is eroding at an unacceptable rate.

An acceptable rate is one that can be tolerated indefinitely without reducing production. For most cropland soils, this annual rate ranges from 3 to 5 tons per acre. In this range, 1 inch of topsoil is lost every 30 to 50 years.

The 1977 National Resource Inventory conducted by USDA estimated the average annual sheet and rill erosion rate for all cropland at 4.7 tons per acre. This soil loss ranged from less than 1 ton per acre to over 40 tons.

More than 35 percent of cropland in the Corn Belt, the Delta States, the Appalachian States, and the

Southeastern States has annual erosion rates exceeding 5 tons per acre.

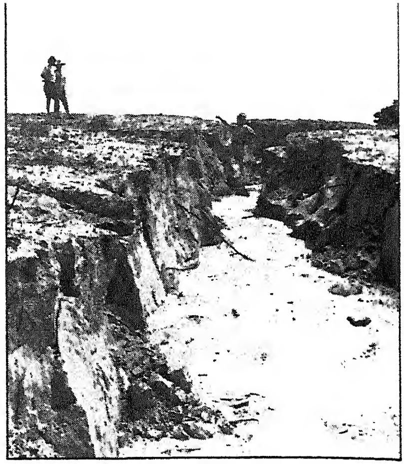
Erosion affects productivity in a major way because it removes surface layers which contain most of the organic matter, fine soil particles, and plant nutrients. Thus, erosion decreases the water-holding capacity, nutrient content, and tilth. (Tilth, or workability, is the physical condition of soil that relates to its ease of tillage and cultivation, and to its fitness as a seedbed.)

Some studies conducted by USDA under the Soil and Water Conservation Act of 1977 indicate that loss of an inch of topsoil may reduce future corn yields by 3 to 4 bushels per acre. A similar study in the Southern Piedmont indicates that a 6-inch reduction in topsoil may have reduced average crop yields by 41 percent. More sophisticated studies are underway to determine the correlation between soil loss and productivity by isolating soil loss as the only variable in experiments.

Effects of erosion upon productivity depend on the kind of soil and soil depth in a given area. In areas where the topsoil is only 10 to 15 inches deep, the loss of 6 inches of topsoil may reduce yields by 20 to 42 percent. In other areas where the topsoil is 15 to 24 inches deep, the loss of 6 inches may reduce yields only 2 to 3 percent.

Reservoirs Affected

Besides the loss of productivity, gullys from erosion may limit equipment operations by making parts of the field difficult or impossible to reach. Also, soil removed from the field is deposited in streams, lakes, rivers, road ditches, and on top of other cropland.



D.M. OLIVER

Runoff water from a single storm caused this shoulder-high gully on a farm in Alabama. Gullys not only reduce soil producitivity but also seriously limit farm equipment operation.

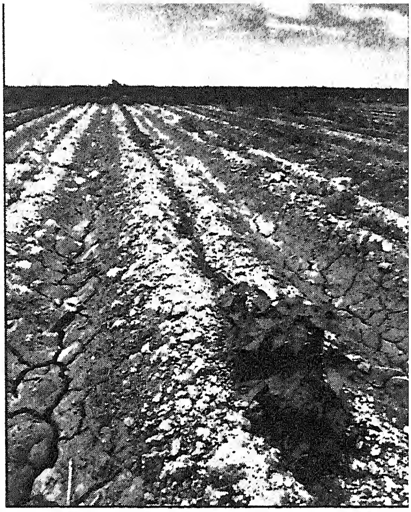
Fish, wildlife, and reservoir capacity are affected, and millions of dollars are spent annually to dredge harbors and ship channels to clear them of silt. Nutrients and pesticides that are beneficial on the land become pollutants when attached to sediment and carried into water bodies.

In determining which measures to apply in a given location, one needs to know the factors controlling the erosion rate. These include physical and chemical properties of the soil (texture, structure, organic matter content, and porosity), length and percent of slope, intensity of rainfall, wind intensities, surface cover, and management.

Soils with a large percentage of silt are subject to high rates of water erosion. Coarse-textured soils and those with a high content of organic matter are less erodible.

Plants or crop residues covering the soil surface (vegetative cover)

Conservation practices such as strip cropping and contouring greatly reduce the threat of soil erosion by slowing down runoff water from rainstorms.



Salt accumulation in the soil — which has killed the plants in this California field — is a serious problem in many irrigated areas, especially the West. An estimated 20,000 acres are damaged each year.

protect soil from erosion by making it more difficult for wind and water to reach the soil to detach and remove soil particles. Vegetative cover reduces the rate of runoff and increases infiltration.

Following are some proven erosion control measures:

Terraces are ridges built across sloping fields at right angles to the slope, to reduce the length of the slope. *Strip cropping* is planting sod crops (clover, for example) which protect the soil, in alternating strips with row crops, which offer less protection. *Contour tillage* is tilling the soil and planting the crops across the slopes and on the contour, rather than up and down the slopes.

Conservation tillage leaves residue of a previous crop on the field when a new one is planted. The residue shields the soil from wind and rain, acts as a mulch to reduce evaporation, and eventually decays and is incorporated into the soil, increasing its organic matter content.

Wind breaks (or shelterbelts) are trees or shrubs planted in long strip to shelter fields and farmsteads fron wind. *Diversions* are ditches constructed across the slope to slow down and divert the flow of water and to reduce the length of the slope.

Land use change means taking highly erodible or erosion-damaged soils out of cultivation and planting them in grass or other close-grown, noncultivated vegetation. They can still contribute to food production by growing hay or providing pasture for animals.

Salinity, Alkalinization

Some of the highest crop yields are produced with irrigation. Irrigation allows farmers to apply water whenever it is needed to maintain plant growth. Most fresh vegetables produced in the United States are grown under irrigation.

But irrigation can lead to accumu

lation of salts in the soil. When the cations of calcium, magnesium, and sodium and the anions of sulfate, chloride, and bicarbonate have accumulated in the soil, a *saline* condition exists. When the dissolved salts form soda or highly alkaline compounds, an *alkaline* condition exists.

Between 150,000 to 200,000 acres of cropland have been eliminated from production, or have had production significantly reduced, by salt problems. An estimated 20,000 additional acres are being damaged each year. The major salt accumulation problems are in arid and semiarid portions of the 11 Western States.

Other Changes

Fertility is the quality of a soil that enables it to provide nutrients in adequate amounts and in the proper balance for the growth of specific plants, when other growth factors—such as light, moisture, temperature, and soil physical condition—are favorable.

Soil structure is the combination or arrangement of primary soil particles into secondary particles. Shape, degree of distinctness, and size of soil particles are considered in defining the structure.

Soil organic matter can be removed by erosion or by oxidation. Most of the organic matter, which is decomposed plant and animal residues, is located in top layers of soil. Surface erosion by wind and water removes the surface layer and, therefore, organic matter.

Deterioration of soil structure and tilth can be caused by a number of things, including loss of organic matter, tilling the soil under wet conditions, and using heavy equipment where weight of the equipment is not properly dispersed on large tracks or tires.

Deterioration of tilth and structure can lead to reduced water infiltration and water-holding capacity, reduced natural fertility, and increased erosion rates. If measures are not taken to restore the soil to its proper structure, tilth, and organic matter, their loss will have a snowball effect. Soil fertility and the infiltration rate will decrease, and organic matter content will decrease even more.

As a result, water runoff and erosion will increase. The erosion will remove still more organic matter and further decrease fertility, thereby compounding the existing problem.

Corrective Steps

Soil tilth, structure, fertility, and organic matter content of the soil can be improved through corrective management practices. These include:

- Increasing sod crops in the rotation
- Using cover crops to reduce erosion and add organic matter
- Avoiding tillage of the soil when it is wet
- Decreasing the size of equipment used, or increasing its wheel or track size
- Using conservation tillage
- Applying needed lime and fertilizer to keep fertility high
- Providing needed drainage
- Using pesticides judiciously and in accordance with the manufacturer's instructions

Pesticides, such as insecticides, herbicides, and fungicides, are chemical agents, used to control specific organisms. Their use has enabled farmers to increase yields and reduce crop damage. However, some scien-

tists suspect that the long-term use of these chemicals has a detrimental effect on the soil's productive capability.

Additional research is needed to determine what effects pesticides have on soil micro-organisms, earthworms, natural vegetation, cover crops, soil organic matter, structure, and tilth. Research is also needed to determine the long-term effects of pesticide buildup in soil.

Sludge, Acid Rain

Currently, 25 percent of the sludge produced by sewage treatment plants is applied to land, some of which is used for crop production. Effects on productivity as a result of applying sludge to cropland are not clear. The major soil pollution potential is heavy metals.

Heavy metals such as manganese, iron, aluminum, chromium, arsenic, selenium, antimony, lead, and mercury are often found in sludge but pose minimal hazards to plant growth. However, some of the heavy metals that are listed (arsenic, selenium, lead, and mercury) and others such as cadmium, copper, molybdenum, nickel, and zinc can accumulate in plants and may pose a hazard to people and livestock eating them.

Use of fossil fuels, such as coal and oil, releases an estimated 150 million metric tons of the oxides of nitrogen and sulfur into the atmosphere each year. Complex chemical reactions can convert an unknown percentage of these pollutants to acids that are then returned to the earth as acid snow or rain.

Most studies of "acid rain" deal with its effect on lakes, streams, and aquatic life. There is some evidence that acid rain has a negative effect on plants.

In areas having acid soils, acid rain may intensify the soil acidity problem. Together, these may reduce productivity in areas where acid rain occurs—principally in the Northeast United States. However, the suspected correlation between acid rain and productivity has not yet been documented.

Summation

To sum up, the United States must maintain high-quality soil resources if the Nation is to produce adequate food for home and export.

Increased erosion, salinity and alkalinity, and pesticide residue buildup are unintended side effects of our highly productive, intensive agricultural system.

Clearly the major degradations are soil erosion and salt buildups, and much is known about correcting these problems. But we need to know a great deal more about the effects of pesticides, other chemicals, and heavy metals upon soils and plant growth, and to develop ways to combat any adverse effects.

Existing information indicates that some steps to control soil degradation are not cost-effective in the short term. We need to identify those benefits to society that result from correcting soil degradation, and to develop research and cost-sharing programs to assist landowners in applying the most efficient and effective measures.

Lloyd E. Wright is a Land Use Planner with Soil Conservation Service.

Whoa There! Let's Smarten Up on Land Use

By Howard C. Tankersley

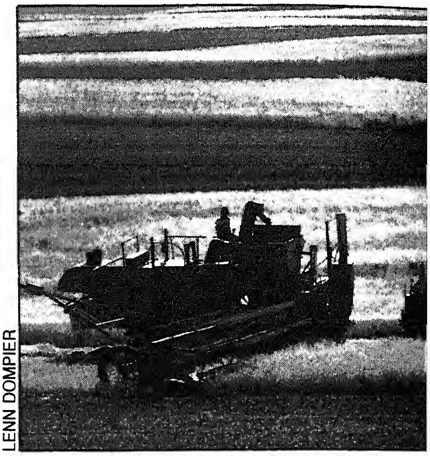
The United States has about 1.36 billion acres of nonfederal agricultural lands. Of these, 413 million acres are cropland, 414 million rangeland, 376 million forest land, 133 million pastureland, and 23 million in other farm uses. More than 99 percent of this land is privately owned; the remainder is owned by State and local governments.

For generations this land, together with our public rangelands, has met our needs for domestic consumption and foreign trade in food, fiber, wood, and other agricultural products. The question important to every American and to millions of people in other regions of the world, however, is whether it will meet those needs in the future. The world population is expected to increase 30 to 50 percent to an estimated 6.2 billion by the year 2000 and to nearly 7 billion by the year 2030.

Compounding the question as to our Nation's ability to produce adequate supplies of food, fiber, and wood are uncertainties about possible needs we will face to produce other kinds of commodities. These include biomass for energy production and a range of agriculturally produced strategic and essential industrial materials now imported.

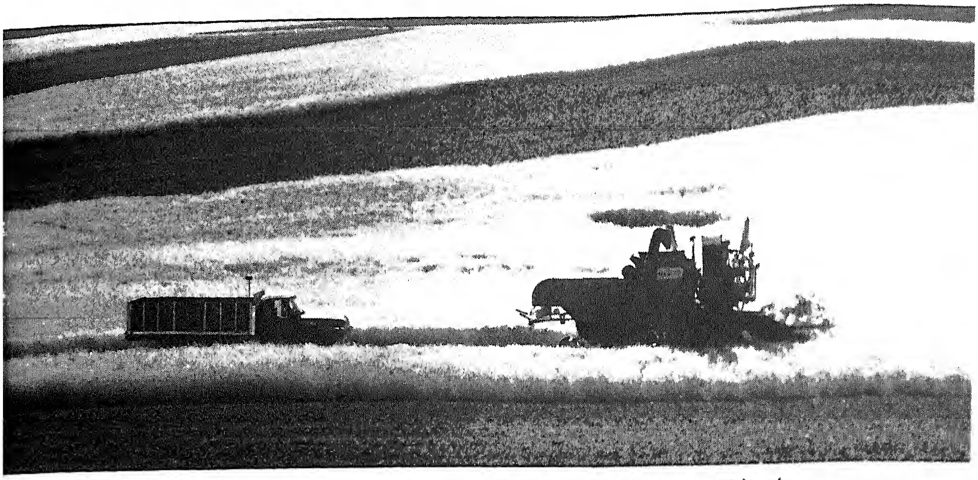
Demands and the Supply

According to assessments undertaken implementing the Soil and Water Resources Act of 1977, by the year 2030 the United States will need to produce about 462 million acres of crops to meet domestic consumption and foreign trade requirements. This figure is based on assumptions that foreign trade will not exceed the 1975-1977 level, that productivity per acre will continue to increase at 1.1 percent per year as a result of technological advances, and that our most productive land will continue to be used for agricultural production.



LENN DOMPIER

In addition to the 413 million acres of cropland, the Nation has about 127 million acres of land that could be converted from present uses to cropland. These 540 million acres are considered to be the U.S. cropland base—the total acreage of land that can be used for crop production without incurring unreasonable production costs or inducing devastating



America's farmland has sustained us and helped feed many foreign countries for generations. But a key question is how long can we continue functioning as breadbasket to the world faced with a shrinking farmland base and growing world population.

levels of soil erosion. However, nearly all the 127 million acres are already being used to produce other agricultural products such as timber and red meat. Any shift of those acres to crop production will mean a decrease in these products.

At the same time, the National Agricultural Lands Study shows that about a million acres of these lands are being converted annually to uses other than agricultural production. At that rate, we will lose about 50 million acres of our current cropland base by the year 2030, leaving us a base of about 490 million acres. This should be sufficient to produce food and fiber to meet domestic consumption and foreign trade requirements at that time—if productivity increases by 1.1 percent per year. If it should increase at a lesser rate, we will be short of cropland.

More than the 540 million acres of land could be used for crop production in the short term. But to use fragile and marginal lands for that purpose, the United States must be willing to incur losses of other products, to pay much higher prices for food and fiber, and to accommodate severe degradation of our natural resources. We would have to eliminate some hardwood forests, drain large areas of wetlands, and live with high levels of erosion on fragile and marginal soils.

The costs: decreased timber or wood production; decreased seafood production and marine life; decreased wildlife habitat; increased stream siltation and surface water pollution.

degradation of the underground water supply; higher outlays for flood control and rehabilitation; increased expenditures for dredging and other means of mitigating downstream siltation; and, eventually, decreased productivity of our agricultural land base.

Strategic Materials

Furthermore, the United States depends on other nations for many industrial materials and manufactured products important to U.S. industry. Some of these, such as natural rubber, sperm whale oil, and castor oil, are classified by law as being "strategic"—meaning critical to defense. Others, called "essential," are required by industry to continue manufacturing those things we all depend upon from day to day.

According to scientists at the Agricultural Research Service Regional Laboratory at Peoria, Ill., many of these materials can be produced from plants that can be grown in the United States. In addition, farm-produced biosynthetic hydrocarbons from vegetable and seed oils can replace imported oil used in manufacturing plastics, synthetic fibers, industrial coatings, printing ink, lubricants, adhesives, and waxes. The United States spends an estimated $27 billion annually to import such products. An additional $8 to $9 billion is for importing petroleum feedstocks used in manufacturing industrial materials.

Technically, it is now possible to substitute U.S.-grown products for a large portion of our imported materials and to replace an estimated 238 million barrels of oil used in the petrochemicals industry every year. Should the prices of imports increase and should the political and economic stability of supplying nations erode, we may have to produce these materials at home.

Domestic production of between one-third and one-half of these materials in the year 2030 would require an estimated 60 million acres of crops in addition to the 462 million acres for food and fiber. This level of production would assure the United States of supplies. It also would provide needed leverage in the world market and reduce competition among free nations for the world's limited supply of these materials.

The United States has also found itself dependent on other nations for oil, our major source of energy. Much attention has been given to how we can become more self-sufficient. One strategy is the production of biomass for fuel. If the United States is to produce energy from biomass equal to 10 percent of our gasoline needs, between 60 and 80 million acres of cropland will have to be devoted to that purpose.

Some Tradeoffs

Given these needs, the total potential demand for cropland in the United States by the year 2030 may be calculated to range from 462 million to 602 million acres. Even if conditions require that we use only 462 million acres of our agricultural land to produce crops, we will be forced to make some tradeoffs.

If we can reduce the rate of conversion of agricultural lands to other uses by half during the next 50 years, we will have about 396 million acres of cropland in the year 2030. This means the Nation would need to convert 66 million acres of forest land, rangeland, pastureland, and

other farmland to crop production.

Should conditions require that the Nation use 582 million acres for crop production in 2030, all cropland and all potential cropland would be in use and about 134 million acres of marginal or fragile land would be cropped. At the same time, the Nation would be producing less wood or timber, less range forage, and less pasture grass. The Nation would be trading off meat, wood or timber, and dairy products for crops.

Demand for wood in the United States is expected to increase significantly. For instance, annual lumber consumption is expected to go from 47 billion board feet in 1977 to 61 billion in 1990, a 30 percent increase in 13 years.

Expected plywood demand follows a similar pattern, rising from 22 billion board feet in 1977 to 31 billion in 1990. Particle board, hardboard, and insulation demand is expected to go from 13 billion board feet in 1976 to 37 billion in 2030. Pulpwood demand is expected to increase from 75 million cords in 1977 to 105 million in 1990.

About 58 percent of the Nation's commercial timberland is privately owned, and that is where the greatest potential for increased production exists. The problem is, these are the lands from which about 31 million acres that might be converted to cropland would come. If converted to cropland, the Nation's ability to meet its demand for forest products will be impaired. That is the tradeoff—forest products for food, fiber, and other commodities.

Milk and Meat—or Cereal

Another problem in converting all the potential croplands to crop production is the need to retain a highly productive portion of the agricultural land base for forage. About 64 percent of the Nation's rangeland and nearly all the pastureland are privately owned. Private rangeland accounts for about 80 percent of the production of livestock from grazing.

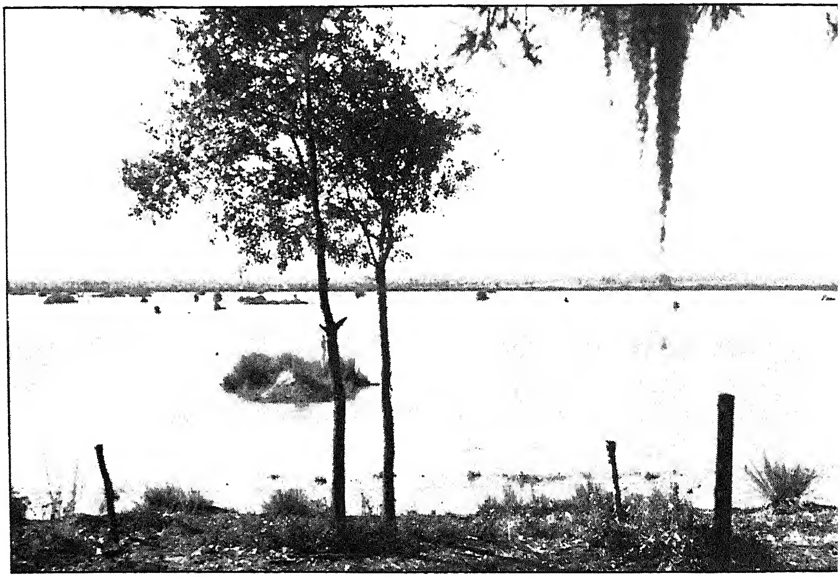
Demand for range forage is closely related to the Nation's demand for red meat and the availability of cost-competitive livestock feeds from other sources. Studies undertaken in implementing the Resources Protection Act suggest that rising energy costs and increased demand for grain for human consumption will make range and pasture forage more economical livestock feed than feed grains and harvested forage (hay).

This is another tradeoff. We will have to reduce the amounts of milk and meat in our diet and replace them with cereals or other foodstuffs. About 39 million acres of the lands that can be converted to crop production would come from our best rangelands, and about 51 million acres would come from pasturelands.

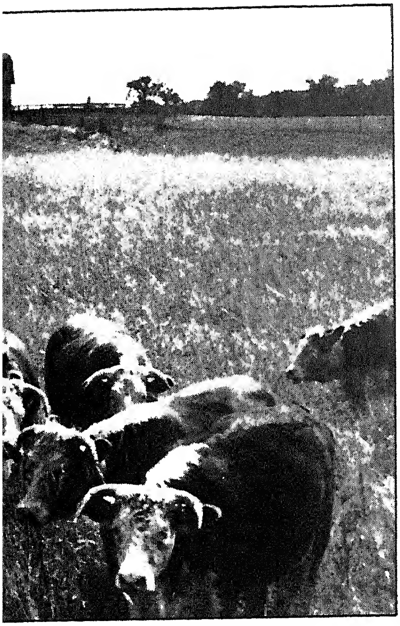
Studies have shown that commercial cattle ranches in New Mexico and Colorado produce between 9 and 14 pounds of beef per acre per year. At these rates, conversion of 39 million acres of range to crop production will reduce beef production by an amount equal to the current annual consumption of beef by between 2.6 to 4.1 million Americans.

The 51 million acres of pastureland are more than 38 percent of total U.S. pastureland. If we convert them to crop production, we will have to feed dairy cows more grain. This means we will have to pay significantly higher prices for milk or use alternative products in our diet.

If we are to expand cropland acreage, much of it will come out of existing pasture, range, and woodland. Yet this land is essential in producing red meat, milk, and timber.



If estuaries and wetlands are drained and filled for crop production the result would be a serious reduction in seafood yield and habitat for waterfowl.



ERV COLE

Seafood, Wildlife—or Crops

Between 1954 and 1978, an estimated 100,000 acres of wetlands were lost annually—about 36 percent of the total U.S. wetlands. They were converted to farming and other uses, not by massive Federal projects but by individuals making thousands of small changes in these lands. Of particular concern are those in coastal areas which directly support U.S. fisheries, and those further inland but which provide flood control, habitat for wildlife, and other benefits.

In 1969, 60 percent of the U.S. population lived in coastal zones. By 1990, it is expected that about 75 percent of the population will live in these areas. They are the areas that provide food and shelter for waterfowl and for fish, crustaceans, and mollusks that are utilized by an estimated two-thirds of the world's fisheries.

According to marine biologists, some 60 to 80 percent of commercial marine fisheries species depend upon estuarine zones during part or all of their life cycles. These zones include estuaries, defined as semi-enclosed bodies of water such as bays, lagoons, or mouths of rivers where seawater mixes with fresh water; coastal wetlands; shallows; and coral reefs.

The estuarine zones are critically important to global food supplies. They sustain a food chain that extends upwards through the food cycle and ultimately supports diverse species of edible fish, waterfowl, and people.

Further inland are wetlands that have a different function. They provide wildlife habitat and feed for a variety of migratory waterfowl and other animals native to these areas. They also provide freshwater fishing and natural flood control by absorbing runoff from heavy rains or winter snows and releasing it gradually into the streams they feed. They prevent downstream siltation by serving as catch basins, thus protecting our streams and estuaries.

Spoiling of estuaries and other wetlands by conversion to farming or by pollution from chemicals or siltation decreases their productivity and that of the fisheries they support. Our shellfisheries, one indicator of the health of coastal ecosystems, have shown steady declines.

Oyster harvests have dropped from 90 million pounds in 1929 to an average landing of 54 million pounds in the 1970's. Clam harvests peaked in the 1950's, were stable until 1975, and have since declined. Yet in 1976 a total of 6 billion pounds of fish and shellfish was harvested by U.S. operators. This $5.5 billion industry

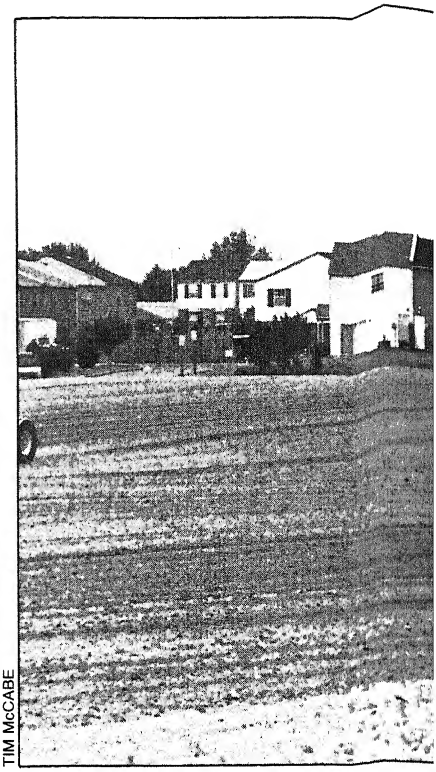
employs about 250,000 people and provides about 28 pounds of seafood for every American.

Further reductions in our wetlands will mean more cuts in seafood yield for the United States and for much of the rest of the world. That is the tradeoff if we convert wetlands to croplands.

Four Major Choices

The people of the United States eventually will have to make at least four major choices. The choices will be made either purposefully as a product of informed discussion and decision, or they will be made by default.

The first choice is whether to allow unconstrained, continued conversion of an estimated 3 million acres of agricultural land to other uses each year. About 1 million of these are our prime farmlands—the best we have. Crops can be produced at least cost and with the least effect on the quality of our natural resources on these lands.

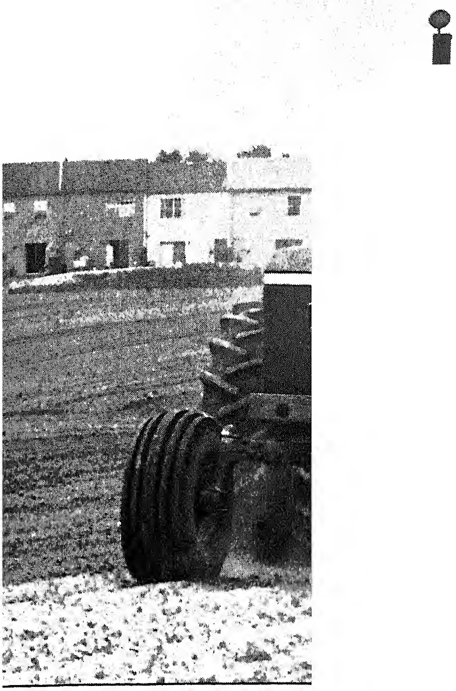


TIM McCABE

One effect of these conversions is the reduction in our capacity to produce agricultural products. Another effect is on the well-being and vitality of our large and small cities, towns, villages, and other urbanized areas.

In July 1980, a report titled "Compact Cities: Energy Savings Strategies for the Eighties" was issued by the Committee on Banking, Finance, and Urban Affairs of the U.S. House of Representatives. The title may be misleading. Of the 32 recommendations the Committee makes in the report, 21 deal with the inequities and costs of converting agricultural land to urban uses—housing, commerce, industry, transportation, and related uses.

In the introduction, the report states that "Suburban and exurban sprawl is splattering industrial, retail, and residential development across the countryside. It is both a city and a farm problem. It is sapping the vitality of large and small cities, devouring farmland at a dangerous rate, and wasting energy at every turn. It makes mass transit unfeasible in many areas, makes commuters excessively reliant on autos that have to travel greater distances, leaves in-city facilities underused, and requires duplication of these facilities as existing communities are abandoned."



Townhouses rise in the background as a farmer prepares his remaining land for a corn crop. Each year an estimated 3 million acres of rural land are converted to non-agricultural uses. One million acres is prime farmland.

Unused Urban Land

The report points out that it is not necessary to use agricultural land for urban expansion since 22 to 25 percent of the privately owned land is vacant in our central cities of 100,000 population or more.

Other data collected for the study show that between 12 and 18 percent of the privately owned land is vacant in towns and cities of between 2,500 and 100,000 population. If the peripheral boundaries of these areas are considered (the urbanized area including general boundaries of the municipality and adjacent urbanized areas), this percentage will more than double in many areas of the United States.

These figures become even larger when one considers that only 32 percent of all the land that is being used in urban areas is devoted to housing, with 55 percent devoted to streets and other public uses.

In other words, with today's costs and accompanying trends in housing, the Nation's cities, towns, villages, and other urbanized areas could provide for nearly double the current population without expanding their peripheral boundaries. The report also suggests ways of causing this to happen.

The public choice—shall we continue to convert agricultural land to urban uses, empty out our cities and towns, duplicate facilities in new areas, and decrease our agricultural production capacity; or shall we develop compact urbanized areas and retain for the future as much capacity as we have now to produce food, fiber, wood, and any other agricultural products we may need?

Seafood Vs Soybeans

A second public choice is whether to allow continued conversion of wetlands to farming and to urban uses or whether to retain them to support U.S. and worldwide fisheries. The underlying presumption is that we can choose to eat seafood or soybeans. If we choose soybeans, we put some percentage of the 250,000 people who are employed in the U.S. seafood harvest out of business and reduce seafood yields in two-thirds of the world's fisheries.

A third choice the people of the United States must make is whether the United States will continue to trade food, fiber, and forest products on the international market. Today, agricultural trade pays about half our oil import bill. Can the United States afford not to trade agricultural products?

The fourth major choice will be between continued dependence on other nations for energy and a range of strategic and essential industry materials, or a conscious movement toward self-sufficiency in these products.

None of these choices can be made in isolation from the others. Individual preferences will be determined on the basis of beliefs and values. The final resolution must be made somewhere between the extremes of those who would allow the market to make all determinations on allocation and uses of resources, and those who believe that the futur public welfare transcends all marke effects.

America's citizens and policymakers must become aware of the trends the tradeoffs, and the major choices now. If we choose to be prudent—ye another public choice—there is still a little time.

Further Reading:

Agricultural Land Use Shifts and Cropland Potential, Thomas Schenarts, available from Soil Conservation Service, USDA, Room 6117-S, Washington, DC 20250. Free.

America's Coasts in the 80's, The Coast Alliance, Center for Environmental Education, 1925 K Street, N.W., Washington, DC 20006. Fre

Farmland or Wasteland: A Time to Choose, R. Neil Sampson, Rodale Press, 33 E. Minor Street, Emmaus PA 18049. $16.95.

Land and Food: The Preservation o U.S. Farmland, Charles E. Little, American Land Forum, 5410 Grosvenor Lane, Bethesda, MD 20814. $3.75.

National Agricultural Lands Stud Final Report 1981, #041-011-00062- for sale from Superintendent of Documents, U.S. Government Prin ing Office, Washington, DC 20402. $4.75.

Howard C. Tankersley is Director of Land Use, Soil Conservation Service.

Section Four

Marketing—Marvels and Missteps

C. OLIVIA CARLISLE

The Food Mix That Keeps Monica Happy

By Olan D. Forker

Marketing links the farmers who produce food and the millions who consume it. If efficiently organized and properly functioning, marketing conveys to producers, processors and distributors the desires and needs of consumers throughout this country, and in fact the world.

It can help a young consumer such as Monica have some variety in her diet so that she won't have to eat hamburgers again, and again, and again. But it will provide her and her family hamburger when they want hamburger.

Monica likes variety. If she or her family has the money, and the marketing system works right, she will get the variety she wants within the ability of producers and marketers to provide it. But if the system doesn't do its job, Monica might not even have hamburgers. She might have only wheat flour or beans. Or she might have only those items that a monopolistic firm, or a monopolistic governmental agency, might want or be able to provide for her and the millions like her.

An efficient marketing system is run by individuals who have a consumer-oriented philosophy and a desire and ability to shift their productive capacity,within resource and financial constraints, to satisfy the ever-changing needs and desires of a growing U.S. population and a growing and changing world demand.

Creativity

In many cases, consumers know what they want only in terms of what is available. It is the responsibility of the producers, processors and distributors then to be creative and to think through the kinds of possible ways they might provide food and services, alter their production capacity, develop new enterprises, change their product form, move it to a different location, or store it until some later time, and identify consumer desires for quality, variety, and services.

The marketing process may begin from the consumer end or the producer end of the channel. But marketing really starts with Monica the consumer, not with the producer. Economist Adam Smith said many years ago that consumption is the sole end and purpose of all production. Consumption is also the sole end and purpose of all marketing activities.

An estimated 7.2 million workers are directly involved in marketing, manufacturing, processing, and distributing food. About an equal number or more are involved indirectly in transportation, in providing information (for example, the market news service), energy, advertising and promotion, quality, and health inspection by government agencies, and the many other services needed to provide effective communication on supplies, prices, and inventories. In carrying out their productive or communicative functions, these

YUEN-GI YEE

Carrots are sorted by hand before packaging at a processing plant in Lake Gem, Fla. An estimated 7.2 million workers are directly involved in marketing, manufacturing, processing, and distributing food.

workers add value to the food items they handle.

In 1980 they added $183 billion to the food domestically produced and consumed in the United States. Thus over two thirds, or 68 percent, of the total value paid by consumers for domestically produced farm foods ($269 billion) was required to cover the costs of the services involved in marketing.

The Marketing Tab

Of the $183 billion marketing bill in 1980, some 45 percent was for direct labor costs, 12 percent for packaging, 8 percent for transportation costs, and 5 percent for fuel and electricity in processing. Corporate profits before taxes accounted for 5 percent of the marketing bill, while 25 percent of the marketing bill covered a large number of other items such as taxes, advertising and promotion, and distribution costs other than transportation.

The marketing function has a communicative dimension, passing information from producers to consumers and from consumers to producers. It has a productive dimension which requires the joining of labor and capital to a commodity to add value, and there is a dimension of competition and trade.

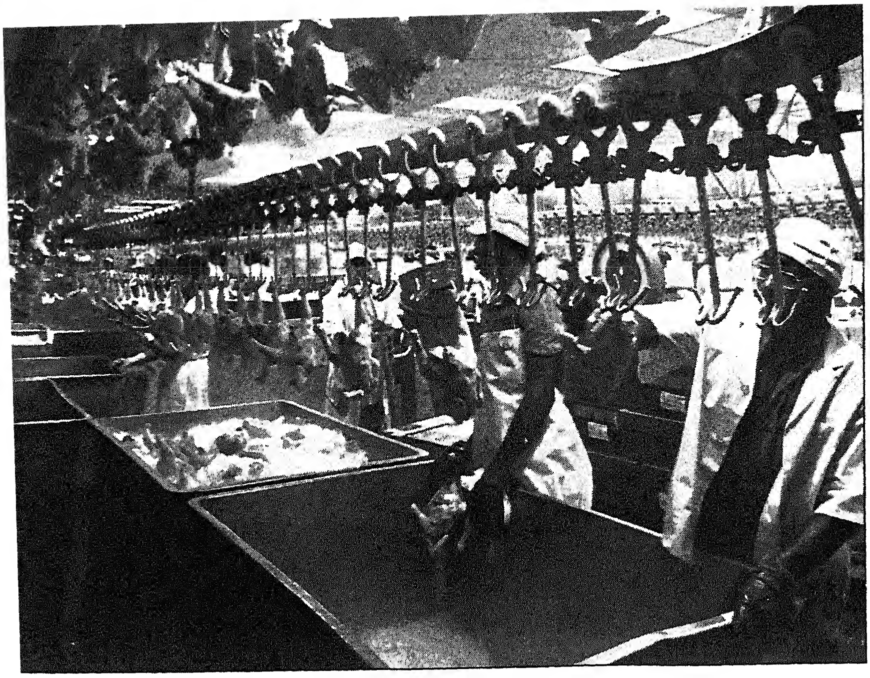
Price is probably the primary means of communication in a market economy. Monica's mother paid out perhaps $1.99 a pound for the hamburger her father was grilling. The reason her father was fixing hamburgers rather than steaks might be because the family members felt that at that price, hamburgers were a better value.

Their neighbors on the same evening might have been grilling steaks because, facing the same price situation, steaks seemed a better value to them.

Chicken or Beef

Such comparative statements could be made about all the food items available to consumers in a particular community.

If the price of chicken increases at a slower rate than the price of beef, some consumers, but not all, will buy more chicken and less beef. In this way, consumers inform those in the marketplace—the processors, distributors, retailers, and producers—that for the prices available to them



FRED WARD

hickens destined for America's dinner tables pass through this uge processing plant where in minutes they are killed, dressed, in- ɔected, cutup, packaged and frozen. How many chickens these ıd other plants produce depend in large part on consumer demand ır chickens.

t that time, they will eat more ıicken and less beef. Thus, production and consumption expands and ›ntracts in response to price ıanges so that balances occur.

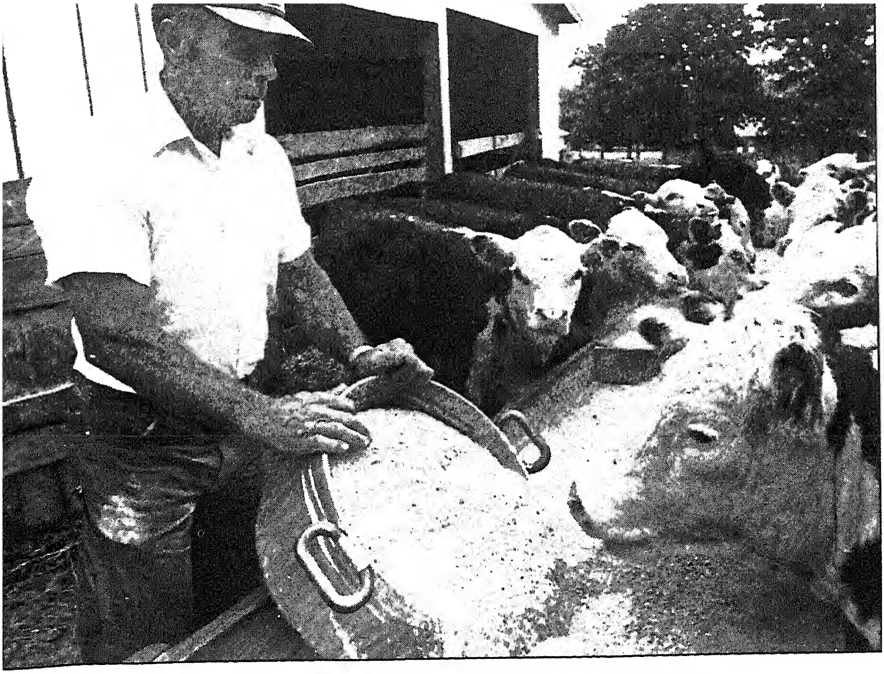
Consumers have indicated to marɜters over the years that they prefer ›me hamburgers with additional ·rvices, when they buy it at a fast od market rather than the grocery ore. In this way we have seen de- ·lopment of a large number of fast- ɔd chains that deliver hamburgers ıd many other items to consumers, ith many services added.

Of the 7.2 million workers in food ocessing and distribution, almost .lf (50 percent) are involved in rving food for away-from-home nsumption.

Although price is a primary indicator, it is not the only means of communication. The persons involved in distribution have to describe their product or commodity to potential buyers. They inform them of availability through advertising and other forms of communication.

The Government establishes grades and standards to make the communication process simple and efficient.

Individual proprietors and companies add information and become more explicit in describing their goods and services. Consumers learn to identify products, not only by the contents on the label, but also by the name of the company that produces and delivers it to them.



A Missouri farmer feeds grain to his beef cattle to fatten them up. He tries hard to anticipate consumer demands. If he thinks it will be strong for beef he keeps more young females to raise more calves. If he thinks it will be weak, he sends more of his breeding stock to market now.

Distributors learn by experience and from market research that consumers prefer food of particular types, prepared and packaged in different ways. This information is passed back through the system to processors and producers, if the system functions as it should.

Trial and Error

Much of this marketing process evolves through experience and experimentation or by trial and error. It is a complex process and involves many institutions and institutional arrangements. Individual firms negotiate with each other on inputs and for the products they sell.

To facilitate communication, many formal marketing arrangements have evolved such as the Futures Market, Commodity Exchanges, and auctions.

The U.S. Department of Agriculture issues price information on a daily basis for many commodities, both at wholesale and retail levels. Private companies publish information for businessmen to inform them of the going prices for various commodities at the retail and wholesale level, as well as at the farm level.

Labor and capital are needed to process, distribute and store food and food products, and provide a communication network. Most people realize the production nature of food processing and distribution, but do not view the Futures Market or Commodity Exchanges as productive activities. But they are.

Many persons are involved in collecting and disseminating information and in making buy and sell decisions. It is this process, this production yet communication activity, that helps determine the value consumers in the long-run are willing to pay and/or the price at which producers are willing to produce and sell. Thus, there is the cost of communication as well as a cost involved in the production process itself in marketing food.

Farmer Decisions

Farmers have to decide how much of a particular item to produce. They must anticipate the kind of price they might be able to receive for beef or wheat of a particular quality.

Based on their price expectations, farmers commit labor and capital to the production process. It is vital that they have an indication of the desires of consumers so they can make appropriate production decisions.

Likewise, those individuals who buy the farmer's products for processing and distribution must have some idea as to what is available from the farm, and must have an expectation of what consumers want and how much they are willing to pay. The margin of return has to cover the cost of their time and effort and provide them some reasonable profit.

Individuals or firms that are creative and the first to satisfy changing consumer demand often make the most profit. In a market economy, the profit incentive is essential for producers, processors and distributors to make a decision to shift resources, or make a capital investment and a human investment in production.

Someone decided once that it would be profitable to produce beef, slaughter it, extrude some of the meat into hamburger, package it and deliver it to the grocery store where Monica's mother purchased it. When this is not profitable it won't be done.

Competition, Trade

If a marketing activity of a food line is very profitable, and if the system is competitive, one can expect an expansion in production volume by the firms involved or by new entrants. If it is unprofitable, one can expect contraction or elimination of firms.

In general, the U.S. food industry is considered competitive. Consumers buy the foods they want. Producers try to compete against each other to capture as big a share of the approximately $345.7 billion spent by consumers (about 20 percent of all personal consumption expenditures) on all food and beverages.

If the system is competitive, the communication and production link between consumers and producers is probably efficient. If it is not—and there is some evidence of monopolistic tendencies in facets of the food industry—then the link is not as efficient as it could be.

An important element of competiton in the U.S. food industry is foreign trade. Many food items are imported. Some, like coffee and cocoa, are not grown in the United States and must be imported in order to be available. Other items, like cheese, are both imported and produced from domestic milk supplies. The availability of imported food items provides competition and gives consumers an increased number of choices.

Although the United States imports a large volume of food, much

DOUG WILSON

Consumers find thousands of food products on grocery shelves across the Nation. These products originate all across the country and the world.

more is exported. This country is a major food exporter and agricultural exports contribute heavily to the U.S. trade balance. In 1980 the United States exported $40.5 billion worth of agricultural goods and imported $17.3 billion worth.

Exporters and importers alike are elements of the vital link which connects consumers and farmer producers.

If Monica says "What, hamburgers again?" she is voicing a desire for variety. For her and consumers like her to have variety in the food available to them, somebody must create that variety.

A homemaker or cook can do some of this by buying raw staples and then grinding, processing, cooking, mixing, and blending. Or the services can be provided by someone else, a person or a business.

When a business firm provides services it is creating value. If consumers see value in having someone else do some of the processing ar preparation, and if they are willi to pay a person enough to cover c and provide a profit incentive, tl value has been created. If an ent preneur, producer or processor pı duces something that consumers don't really want, then true valı has not been created.

Consumers' desires are always changing as their income levels change, as their experience char as they are exposed to new and ent kinds of foods. The mix of fo and services that consumers act see each day in the supermarke at the roadside stand are the res a continual adjustment process. mans and capital are employed products created. Consumers bu some and not others.

Olan D. Forker is Chairman, Department of Agricultural Econom Cornell University, Ithaca, N.Y.

Heavens Preserve Us—or at Least Our Food

By R.E. Hardenburg and R.L. Handwerk

Increased production of food alone does not solve the world food problem. Food must be preserved or stored in an edible, nutritionally adequate condition until it can be distributed and consumed in and out of season.

Many foods required for good nutrition—such as fruits, vegetables, meat, poultry, fish and the dairy products—are highly perishable. The processes responsible for gradual deterioration and spoilage are complicated and some are not fully understood. They include physical, chemical, biological and microbiological deterioration. There is destruction by insects and rodents, and waste from just not getting food to market on time.

Global food wastage is estimated at 25 to 40 percent, with highest losses in the poorer developing countries. Overall U.S. food losses in marketing were estimated at $14 billion in 1975.

Are such huge food losses inevitable? Or are there better ways of handling and processing to reduce losses? Fortunately, we have the most sophisticated methods and systems in the world to preserve and protect our food supply from the environment and from the myriad of insect and microbial pests.

Major research and extension efforts should be on minimizing food wastage to produce a significant increase in the food supply. This means developing better food preservation to extend storability and maintain quality.

Variety of Techniques

Food today is preserved in a variety of familiar ways: refrigeration, conventional canning, flash freezing, freeze drying, dehydrating and pickling.

Dry storage at ambient temperature is adequate for relatively stabl commodities like cereal grain if the bins or silos are fairly airtight. Provision should be made for forced-air circulation to do some drying and prevent accumulation of moisture, spontaneous heating, and spoilage due to microorganisms. Fumigation facilities to control insects and rodents are desirable.

Refrigeration is the keystone of ou quality protection system for perishable foods. Refrigeration makes it possible for even perishable foods to be shipped long distances by truck, train or ship. Storage life is dramatically increased when the temperature is lowered from 70° to 80° F. to near 32°—from a few days to severa months with some fruits and vegeta bles. For beef, lamb, pork, chicken and fish, storage life at 30° to 32° F. varies from a few days to several weeks.

Fresh asparagus will keep in gooc condition only 1 day at 77° F. but 4 days at 50° and 20 days at 36°. Chilled poultry has a shelf life of only 1 day at 70°, 3 days at 50° and 18 days at 32°.

The most pronounced increase in storage life, however, is obtained when products are frozen and storec at low temperaures. At −20° F., the

possible storage life of many products is 1 to 2 years without significant changes in nutritional and sensory qualities.

The effect of low temperature is to slow down or stop processes contributing to deterioration. It retards respiration and other metabolic activity of living products, aging, ripening, textural and color change, moisture loss and shriveling, insect activity, and spoilage due to invasion by bacteria, fungi, and yeasts.

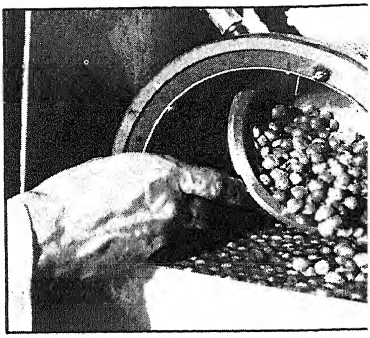
In principle, mechanical refrigeration is simple. To cool a product to a definite temperature and hold it there, it is necessary to absorb from it the surplus heat which it contains, then to protect it against absorption of additional heat from outside sources.

Starting in the Field

Ideally, refrigeration or the cold chain should start right in the field for crops or right after slaughter for animals. It should be continuous during storage and transport and in supermarkets and consumers' homes. However, this can be economically feasible only in countries with a high standard of living.

Fruits and vegetables often are precooled to rapidly remove field heat. This is done by cold air blast, crushed ice, hydrocooling using cold water, or vacuum cooling. Vacuum cooling is widely used for lettuce and certain other leafy vegetables.

Meat is most often chilled by cold air blast. Milk from the milking



Top photo: Carrots go into a vacuum chamber for cooling before shipment. Vacuum cooling is widely used for prolonging the life of certain fresh vegetables.

Directly above: These peas will be frozen to 18° C. (0° F.) in 2 minutes in a solution of table salt, alcohol, and water. The drum will then be drained and the peas spun dry for 15 seconds. Researchers are finding that vegetables frozen in a liquid freezant require 25 percent less energy than in conventional air-blast freezers.

machines flows through sanita tubing into stainless steel tanl where mechanical refrigeratioı begins.

Supermarket display refrige are designed to merchandise fc They provide some refrigeratic required for short-term protect food which is to be sold within days.

Suggested display case temp tures are 35° to 45° F. for prodı and dairy products, 28° to 35°

wrapped meat, and 0° F. or below for frozen foods.

Home refrigerators provide temperatures higher than optimum for extended storage. One survey showed a range from 30° to 55° F., with 37° to 43° the more common range. The intent is to provide satisfactory temperatures for a 2- to 7-day period.

Humidity Control

Control of relative humidity during storage and marketing is nearly as important as control of temperature. Relative humidity not only affects moisture loss from products, as evidenced by shriveling or shrinking, but also affects the activity of decay-causing organisms.

High relative humidity of 90 to 95 percent is recommended for storage of many high-moisture products, such as chilled meat and poultry, eggs and produce. Dry onions and winter squash are exceptions and have less spoilage at much lower relative humidity—about 75 percent. Some other products that keep best at low relative humidity in the range of 50 to 65 percent are flour, candy, and dried fruits.

Food packaging helps retard deterioration from all sources that lower product quality. Packaging should provide physical protection to prevent product crushing and to provide stacking strength for normal handling. Wood boxes, fiberboard cartons, cans and jars provide this protection. Apples are commonly packed in corrugated boxes with molded-pulp trays for each layer of fruit to reduce bruising during long-distance shipment.

Many films (such as cellophane, polyethylene, polypropylene, polyvinylidene chloride, polyester) have been created to meet multiple needs of foods, often with barrier coatings or laminated to other films or foil. Some film-foil laminates are 3- to 6-ply sophisticated packages providing protection from light, heat, moisture and oxygen transfer. It is

B. HUNT ASHBY

Plastic film for individually quick-frozen steaks vastly improves keeping quality of the meat by cutting freezer burn, weight loss, and discoloration.

C.O. CARLISLE

Individually-wrapped heads of iceberg lettuce reach supermarket shelves across the Nation all year round.

not easy to develop flexible packaging to extend shelf life of products such as bread, nuts, cheese, chilled pickles, dried soup mixes, or an aseptic carton or pouch for beef stew or seafood.

The food industry also has its eye on potential energy-saving packaging that allows shorter processing times, less storage space, less spoilage, is lighter in weight, and needs no refrigeration.

Role of Chemicals

Many chemicals are used to supplement refrigeration or to otherwise retard deterioration. These include antioxidants, waxes, mold inhibitors, insecticides, fumigants, antiseptic washes, heat treatments, and various gases.

Fresh eggs sometimes receive a mineral oil coating to prevent moisture evaporation and loss of carbon dioxide. Tomatoes and cucumbers are waxed to retard shriveling. Apples for storage usually are treated with a decay inhibitor such as benomyl, and an antioxidant such as diphenylamine. Jonathan apples may be drenched in calcium chloride to retard softening and breakdown.

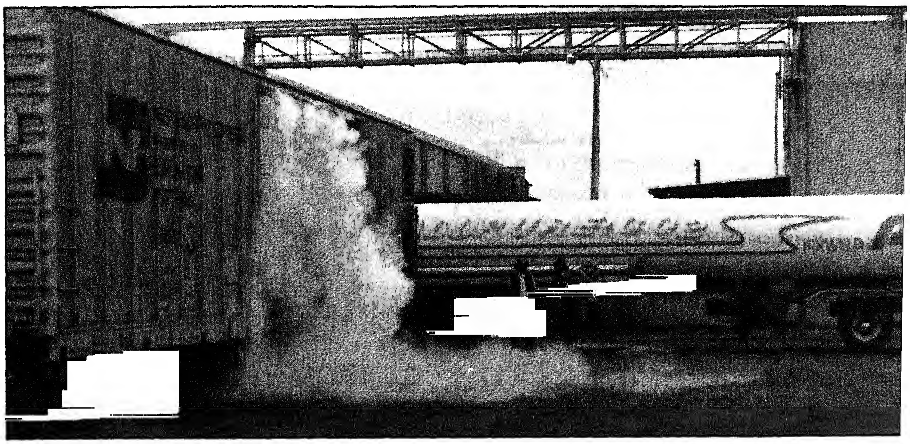
Recent U.S. Department of Agriculture (USDA) research has shown that purging storage silos of corn with 60 percent carbon dioxide for 4 days will give over 95 percent control of most stored-grain insects. Table grapes are fumigated in storage with sulfur dioxide to control mold.

Incorporation of polyphosphates into poultry by adding them to the chilling water will increase shelf life and control loss of moisture. Propionates are extremely useful in controlling molding of bread.

Papayas in Hawaii are treated in hot water at 110° to 120° F. before shipment to control decay.

Controlled Atmosphere

Modified or controlled atmosphere storage (CA) can aid preservation of apples, pears, certain meats and



B. HUNT ASHBY

Because of skyrocketing fuel costs for running compressors on refrigerated railcars, alternative ways to keep perishables cool in shipment are being tried. Here liquefied carbon dioxide is sprayed over the cargo in an ordinary boxcar, turning the load into a huge "ice chest."

some other perishables.

For apples and pears, gas tight cold storage rooms are used with lower than normal oxygen and some carbon dioxide—usually 1.5 to 3 percent oxygen with 1 to 5 percent carbon dioxide and the balance nitrogen. CA storage adds a few months to the life of fruit over normal refrigerated storage. As a result Delicious apples are marketed the year round.

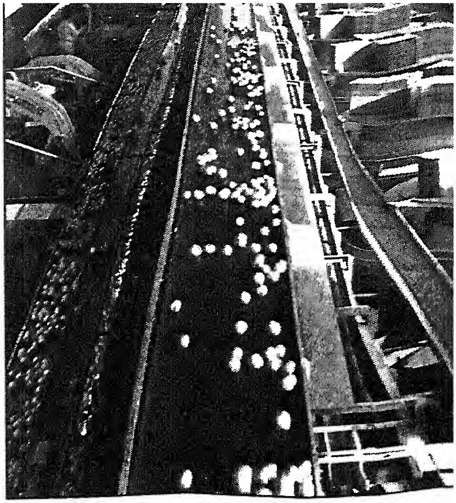
Apples stay crisp and firm longer, and some internal disorders are controlled by CA. Without this technology, some of the apple crop would be lost during market gluts that exceed consumer demands.

A recent modification of CA storage is hypobaric or low-pressure storage (10-100 mm mercury). This provides an atmosphere very low in oxygen, ethylene, and other volatiles that retards ripening and delays deterioration of produce and meat.

Use of modified atmospheres during transport aids quality retention of meat, fresh strawberries. sweet cherries and bananas. The atmosphere is modified by adding dry ice, by injecting gas mixtures from pressurized cylinders, or by letting the food product modify the atmosphere within gas impermeable film bags. Bag-in-a-box packaging has proved very successful for commercial shipment of fresh chicken and pork.

Whole chilled beef carcasses have been shipped from Australia to Great Britain since the 1930's under carbon dioxide atmospheres. Carbon dioxide inhibits growth of bacteria which produce off-flavors and off-odors in raw meat and poultry.

Head lettuce is now being cooled, cored and chopped into salad-size pieces in California. The chopped lettuce is then packed into 10-pound



Fresh apples roll down conveyer belt in a Virginia packing plant where they are sorted, sized, packed, and shipped to locations in all 50 States. Carbon dioxide storage can keep apples crisp and firm longer so some of the crop isn't lost during market gluts that exceed consumer demands.

polyethylene bags. The bags ar
evacuated and back flushed wi
modified atmosphere that inhil
discoloration of cut edges durir
shipping and marketing. Precu
tuce has a 2 weeks shelf life at
This product is very popular w
fast food chains and institution
distributors. There is no trim l
at the point of use.

Year-Round Selection

The array of choices of foods av
able in our supermarkets is in
impressive. Year round we are
select from a variety of vegetal
from artichokes to zucchini, fr
from apples to tangerines, and
seemingly infinite variety of g
and cereal products, meats, po
products, and dairy items.

These selections are not only
available in fresh form, but al
preserved, chilled, canned, froz

pickled, dried, and in many cases may be purchased ready-to-eat.

Primary objective of processing for preservation is to modify raw commodities into stable forms. This insures a safe, wholesome food supply for people living and working in areas far removed from where the crop is grown.

If we were unable to preserve our food but demanded only fresh unprocessed food, we would not only be faced with transporting fresh products over great distances but would have a great number of popular foods available only on a seasonal basis.

Compound this situation with the problem of disposing of the tremendous amount of inedible shells, peels, cores, pits, husks, etc., that are normally removed in preparing food. Consider also the energy costs of home food preservation, the tedious hours in the kitchen, and the spoilage that would result from attempting to hold products fresh until they are consumed.

Food Freezing

Freezing preservation, discovered by ancient civilizations surviving the ravages of wintertime cold, is now used to maintain a great variety of our foods in a relatively unchanged state for a long period of time. This is the principle of food freezing.

Microbial life forms cannot grow and affect food at freezing temperatures. Some natural food enzymes do, however, cause undesirable changes in food when the plant cells are disrupted by freezing. Therefore, most vegetables are "blanched," that is, heated slightly to inactivate enzymes before freezing. Many foods are protected by packaging, usually plastic to avoid moisture loss and exposure to oxygen and sometimes opaque to exclude light.

A great deal of care and expense is required to maintain a package of frozen food in the frozen state, from production until selection from the freezer for final preparation. Preparing, packaging, freezing, storing, shipping, and marketing frozen foods has evolved in recent years to become a fine-tuned system to meet the needs and—yes, the whims of American consumers.

Food is frozen not only for sale at retail but also in bulk for institutions, restaurants, and as a convenient storage form for later use in manufacture of many specialty products, for example, soups and stews.

Another form of frozen foods is available—dehydrofrozen foods. For example, dehydrofrozen potatoes, based on a process developed by USDA in Albany, Calif., are made by precooking potato cubes or slices, evaporating sufficient water to reduce this weight by 50 percent, and then freezing them.

Loss of color, flavor, and texture is much less in early stages of dehydration than in later stages. Thus, by stopping the dehydration halfway through and then freezing, these qualities are conserved to a greater extent than with conventional dehydration. Dehydrofrozen food is less expensive than freeze-dried food and less bulky to store than conventionally frozen food.

Evolution of Canning

Preservation by conventional canning is the only widely used means of preserving food that was invented by modern man. The reason for this becomes obvious when we consider the

major steps involved in canning.

First, one needs a container in which to put the product that is impervious to air, moisture and microorganisms. This container must be durable and capable of withstanding heat, at least the temperature of boiling water. Secondly, a method must be devised to heat the container with its contents to temperatures high enough to kill any microorganisms (temperatures of 212° to 250° F. are commonly used).

The ancients did not have such containers or methods for heating. The first container available that met these requirements was the glass jar. This was soon followed by the can made of tinned steel. Over years, these containers have evolved in size, shape, and kind of closure used.

There have been recent innovations in containers for conventional canned foods. Two-piece aluminum and steel cans are now replacing some of the conventional three-piece containers.

Conventional cans are made of a body and two ends. They require soldering of the side seam of the can body. This operation is costly. And since solder contains lead, extreme care must be exercised in can manufacture to assure that the lead content of foods does not exceed tolerable limits.

The two-piece can requires no solder and the bottom is formed together with the can body. Tin-free steel (chromium plated) has, for some products, replaced the familiar tin can. These innovations reduce container cost and ultimately the price the consumer must pay.

Automatic fillers and check weighers, automatic vacuum testers, sophisticated defect detectors, automatic controls on continuous cook ers to assure adequate processing, and many more advances have helped the canning industry maintain high quality at relatively moderate prices.

Recent Advances

In recent years, with the advent of mechanical harvesting of vegetables a number of innovative changes hav taken place in the vegetable process ing industry. Agriculture, like most industry, has mechanized to keep production costs down.

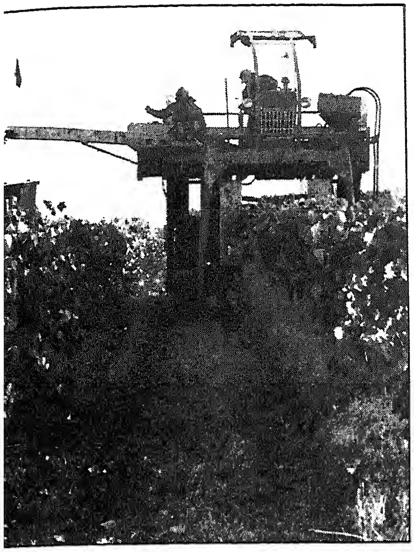
Tomato varieties were developed that lend themselves to mechanical harvesting, that can stand physical abuse from the machine and subsequent hauling, and that have good nutritional and processing qualities

Another advance in tomato produ manufacture is development of bulk storage tanks for concentrated toma to solids. These storage tanks are sterilized and filled each season wit commercially sterile concentrated tomato solids for use throughout th year in preparing a great variety o products requiring tomatoes—soups spaghetti sauce, ketchup, dressings pizza, beans, and a host of other products as well.

Without these advances, tomato products would not be available in such abundance and prices would undoubtedly be much higher.

Research has also made it possib now to package commercially steril products into sterilized containers. This allows use of plastic container instead of metal cans for packing many foods. The result will be mor convenient and cheaper foods.

With the new aseptic system, mi or juices can be commercially ster-


USDA

Vine-straddling mechanical harvesters pick juice grapes. At the end of the row, the high lift dumps grapes into trucks that hold up to 12 tons and tilt for unloading at the processing plant. Many advances have been made in mechanically harvesting vegetables in recent years.

ilized using an ultra-high temperature that is much less damaging to flavor. The milk or juice is then moved under aseptic conditions to the filling equipment.

The packaging material is sterilized with hydrogen peroxide, the container formed, filled, and sealed under aseptic conditions. One then has a commercially sterilized product in a sterilized, sealed container that need not be refrigerated continuously.

Fermented Foods

Preservation by fermentation and by pickling is another great invention of our ancient forebears. They found out that by allowing certain foods to ferment, or by adding fermented liquids to foods, that the food did not spoil and could be held a long time.

Modern science has isolated the organisms that produce the desirable fermentations and defined the optimum environment, nutrients, temperature and other conditions that will safely and efficiently pickle foods. Now controlled fermentations that use pure cultures of microorganisms produce many of our foods. Cheeses, wines, beers, vinegars, pickles, sauerkraut and soy sauce are among the commonly available fermented foods. Recent advances in fermentation technology are making our foods safer and of higher quality.

One of the oldest known methods of food preservation is dehydration. This lowers water content to inhibit growth of microorganisms, thereby bringing spoilage activity almost to a standstill under moisture-proof packaging. Moisture is removed by sun drying, by indoor tunnel or cabinet dehydrators, and by freeze-drying.

Many food processors use dehydrated vegetables to make a broad range of products, for example dried soup mixes, canned and frozen products, condiments, salad dressings, convenience food items, casseroles, and extenders in meat dishes.

Dehydrated foods properly packaged may be stored at room temperature for extended periods, while retaining flavor stability. Also, dehydrated vegetables are lighter in weight and lower in space volume, which translate to reduced handling and storage costs. One pound of freeze-dried mushrooms is equivalent to approximately 13 pounds of fresh product.

Dehydrated garlic and onion products are available in a variety of forms, including powdered, granulated, ground, minced, chopped, and

sliced. One part dry weight of dehydrated ground onion is equivalent in flavor to approximately 13 parts of raw onion as purchased.

One commercial firm dehydrates peppers, carrots, cabbage, celery, chives, green onion, green beans, peas, beets, horseradish, parsley, parsnips, spinach, turnips, and corn. Many of these are available in our markets.

Powdered and granulated vegetable forms will rehydrate within 1 to 10 minutes in cool water. Chopped, diced, sliced, and flaked vegetables are rehydrated by placing them in cool water which is then brought to a boil and allowed to simmer for 15 to 20 minutes.

Current constraints on available water for food processing, costly waste disposal problems, and escalating energy costs present serious problems to food processors. Federal, State and private laboratories recognize this need and are seeking technical solutions.

Processing operations are being studied to find ways to use less water, to reuse water within the processing plant, to reduce waste and the wastewater volume. Energy use surveys have been conducted. These have pointed the way for energy-saving innovations in the processing industry. More efficiency can and will be achieved as we expand our scientific knowledge of the fundamental principles on which innovative changes are based.

Although few fundamentally new methods of food preservation have come along recently, new and better ways to do the job are being developed. The future will see even more evolution in the food industry. With world population growing rapidly, the need is great to protect food during marketing through proper storage and processing to reduce waste.

Further Reading:

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Keeping Food Safe to Eat –A Guide for Homemakers, H&G No. 162, U.S. Department of Agriculture, Office of Governmental and Public Affairs, Washington, DC 20250. Free.

Proceedings of the National Food Loss Conference, available from John O. Early, Agricultural Science Building, Room 30, University of Idaho, Moscow, ID 83843. $5.

Storing Vegetables and Fruits in Basements, Cellars, Outbuildings, and Pits, H&G No. 119, U.S. Department of Agriculture, Office of Governmental and Public Affairs, Washington, DC 20250. Free.

The Technology of Food Preservation, N. Desrosier, 1970, Avi Publishing Co., Westport, CT 06880. $19.

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Truckin' on Down with Your Next Meal

By B.H. Ashby and J.P. Anthony

During the energy crunch, a prime concern is whether we can maintain the unique transportation and distribution system that allows us fast delivery of quality food items over long distances in relatively short periods. Will new technology allow our present system to go on unchanged? Or will skyrocketing fuel prices force development of new food distribution systems?

The total price that consumers pay for food items is heavily influenced by fuel expenses at every link in the distribution chain from field to dinner table. Approximately 5 billion gallons of fuel is used annually to raise, harvest, process, store and handle, transport, refrigerate, retail, and cook the food consumed in the United States. About 1 billion gallons of this fuel is used annually for personal automobile transportation to purchase food at supermarkets and restaurants.

Production of food in the United States is highly concentrated by product in areas which for the most part are far from major consumption areas. Examples are: Florida citrus, Texas onions and meat, California lettuce, and Pacific Northwest potatoes. Will increasing fuel prices turn the economic advantage to more local production of food? The authors feel this is unlikely in the near future. Agricultural production still will decline in areas of urban growth and concentrate even more in the major production areas.

We all are waiting for development of a "miracle fuel" or a cheap replacement for gasoline and diesel fuel that will reduce transportation costs and lower food prices. This also is unlikely. What is happening is that the energy crunch is forcing rapid development of energy-efficient transport equipment and food marketing facilities. Equipment and facilities for transporting, handling, and retailing food most probably will change drastically during the next decade.

Computers to the Rescue

In the near future, computerization most probably will make the greatest impact on fuel savings in food distribution. At present, we have food warehouses in the planning stages where most operations will be computer controlled and mechanically operated.

Computers will select the most efficient pallet stacking patterns and electronically direct the mechanical stacking of food containers on pallets in racks in the warehouse, some as high as 50 feet. Outgoing orders for food products will be entered into the computer which mechanically retrieves the pallet loads from the warehouse and moves them to the loading dock.

Once at the loading dock, computers will determine the loading patterns for stacking the product so every bit of available space in the transport vehicle is used. Computers will be programmed to select the

Hunts Point Terminal Market, covering the lower third of the picture, is where food from all over the world converges to be distributed to over 15 million people in New York City.

most energy-efficient routing for the driver to follow during his delivery to either grocery stores or warehouses.

In the future, trucks will be equipped with their own on-board computers that will take over many product maintenance decisions now made by drivers. For example, when transporting refrigerated food products, the driver enters pretrip information on the specific product to be carried, and the computer will automatically control the proper temperature and humidity. In addition, the computer will control operation of the refrigeration unit for minimum consumption of fuel.

Computerization also will b applied to operation and main nance of the vehicle. Once on highway, the on-board comput select the gearing and operati speed for minimizing fuel cons tion under the existing load an conditions. The computer also add or change the engine's oil tomatically as required.

Engineers predict that futur frigeration for highway trailer be powered by the tractor exh heat, which now is dissipated i the air. Trucks also will be des to minimize aerodynamic drag will have a total new look.

Solar Railcars

The long-distance transport (over 200 miles) of perishable foods most likely will move by railroads, since rail transport is four times more fuel efficient than highway transport. However, the vehicles transporting the food will be intermodal trailers on flatcars or dual-purpose road/rail vehicles.

In the distant future, engineers have proposed individual solar-powered railcars for frozen foods. Essentially, these will be "Flying Dutchman" warehouses on the rails. The sun will heat liquid hydrogen stored in on-board tanks and coils in the car walls for refrigeration. The refrigeration boiloff would be used for motive power, and computers will guide the car to its destination.

In the air, a British firm has recently ordered several cargo blimps or airships. Air cargo is the most energy-intensive mode of transport. Airships can operate on a fraction of the fuel required by jet aircraft and can pick up and deliver food products in areas without elaborate airfield facilities, very possibly at the stores themselves.

A U.S. firm proposed a flatbed jet aircraft that will carry intermodal containers. Refrigerated foods can be shipped on the aircraft in insulated containers without diesel-powered refrigeration, since ambient air temperatures in flight approach −70° F.

Will future technology make refrigeration for food obsolete? Supplying in-transit refrigeration for food products increases fuel consumption from 15 to 30 percent. Warehousing and retail store refrigeration account for large additional demands on energy during food distribution. Current research is aimed at reducing or eliminating the demand for distributing food products under refrigeration to maintain their "fresh-like" state.

Recent developments in sterile milk technology promise to practically eliminate the refrigeration requirements for home delivery of milk and save an estimated one-half billion gallons of fuel annually.

Extending Shelf Life

We are on the brink of technological breakthroughs in gas treatment and packaging which will allow a number of food products to be preserved and delivered in a fresh state without refrigeration. This process will extend shelf life almost indefinitely and reduce undue waste of food in the distribution process.

In summary, our current food distribution systems are diverse and energy-intensive. Energy shortages and rising fuel costs will force changes in the way food gets from the farm to the consumer. The beginnings of these changes already are visible in our everyday life. For example, the warehouse-type food retail outlets are an attempt to hold back food prices by reducing distribution costs.

None of us can predict exactly what will develop over the next decade, but we can be assured of wide ranging changes in the way our food is transported and marketed brought on by the need to conserve and use energy resources more efficiently.

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Pickin' and Choosin' in the Supermarket

By Daniel I. Padberg

The American food system contains many firms and organizations—large and small. Some are very scientific and specialized, others simple and traditional. But the eventual meaning of all these activities comes from the way this system serves the consumer.

Consumers influence the food system through their choices. They express a preference for convenience by buying frozen French fries instead of a bag of potatoes. By patronizing McDonald's, consumers encourage the growth of fast-food places and the decline of some more traditional food channels. When we study consumer choices, we learn something about how Americans want to eat and organize their time—we also learn about how these demands are translated into adjustments in the food system.

One level of choice involves food for serving at home versus buying meals or prepared food for consumption away from home. Several choices are available within each of these channels. Supermarkets provide much of the food for use at home, but roadside stands, bakery shops, and convenience stores are alternatives. Food away from home may be at school, on an airline flight, through a vending machine, or in any of several kinds of restaurants.

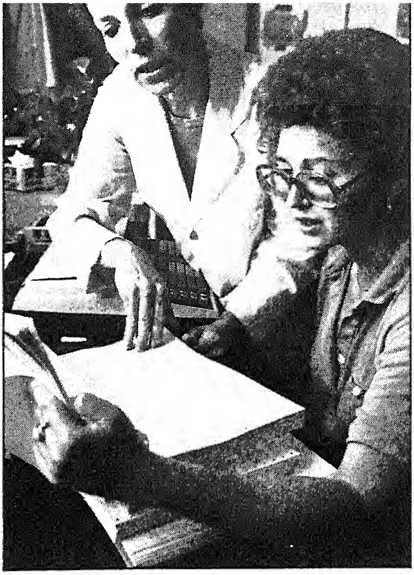
Another level of choice involves the amount of processing done. Shall we have rice or Rice-A-Roni, flour or bread, oranges or orange juice? At still another level, we may like nationally advertised brands or generic brands. The choices offered and the patterns and trends observable have a major effect upon the diet of the American population.

We interpret the trends in consumer food choices in the context of the current socio-economic conditions of our consuming population. A brief summary or description of the typical American consumer may be useful in interpreting consumer behavior.

The most notable aspect of the American consumer is affluence. Even the American consumer on welfare has enormous buying power compared with the three-fourths of the world population who earn less than $600 a year. Today's consumer has twice the real income—after accounting for inflation and taxes—which was enjoyed by the previous generation.

Shift in Women's Role

Another significant aspect of the socio-economic setting is the changing role of women in our culture and economy. The increasing tendency for women to seek personal fulfillment and development in activities outside the household and to seek equality with men in the workplace has a great effect on the food system. In the first place, women working has been a major factor in the increased household affluence. Additionally, it competes for time and reduces the opportunity for meal preparation in the home. This trend creates the



BOB BJORK

With more and more women in professional careers, the time and opportunity for meal preparation in the home is decreasing.

need for convenient food and the ability to pay for it.

In this socio-economic setting, we are not looking for the cheapest food choices. We want a lot of convenience. We want choices that enable a changing lifestyle. We move to a way of living with much less emphasis on the family and homemaking.

This trend takes us away from the less expensive staples to the prepared foods which are more expensive, more packaged, more preserved, etc. Yet we want the less expensive staples available, too. Sometimes the American consumer exhibits inconsistent behavior. We articulate the concepts of frugality developed in our culture for generations while at the same time we are happily adopting the habits of affluence which have become widespread only in the last generation.

Sixty-five percent of 1980 food expenditures by American consumers went for food at home. This share is decreasing over time, as prepared foods become more attractive in restaurants and especially fast food places.

Supermarkets are the biggest stream in the food system, but their share (now over 40 percent) is declining slowly. The supermarket is a very American innovation and a great success in consumer goods distribution. It is efficient in a distribution cost sense, and yet it allows displaying an enormous variety of products. By and large, food received through the supermarket is the best buy if economy is given high priority.

Smaller grocery stores are not called supermarkets, although they may indeed resemble them. (Supermarkets are often defined as grocery stores with over $1 million in annual sales.) These smaller stores are often in locations unsuited for supermarkets. Urban areas too crowded for parking lots and thinly-settled rural areas are examples. These stores sell over 11 percent of the value of food purchases. Convenience stores do another 3.5 percent. Often the selection is narrower and the prices higher in convenience stores.

Specialty food stores include bakery shops, fish markets, dairy stores, butcher shops, etc. They do 4.4 percent of the total, and purchases directly from farmers and fishermen add another 0.6 percent. These food sources may sometimes be cheaper than the supermarket, but that is not the usual case. It is a normal expec-

DAVE WARREN

consumers realize that by buying produce direct from farmers nay get better quality, often at lower prices. But less than one nt of produce is marketed that way.

n, however, that the products distinctive quality and be rec- zably different from the super- cet alternatives in this regard.

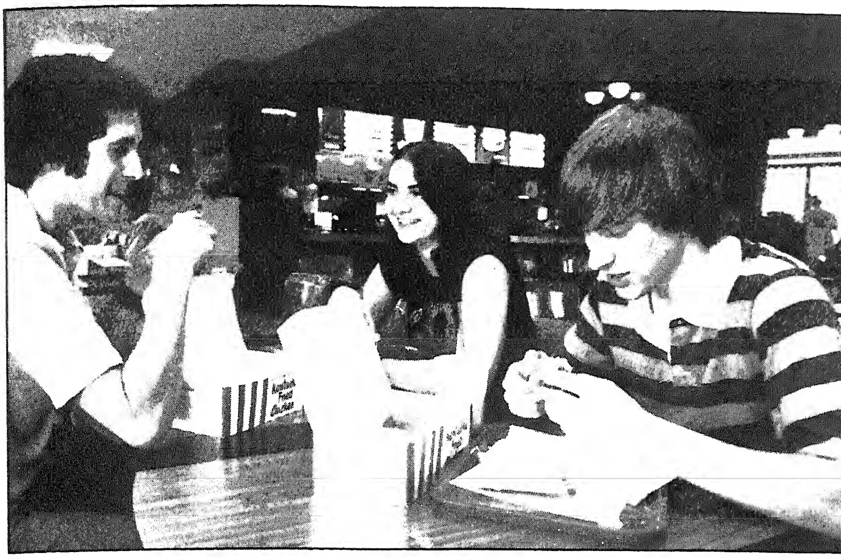
her retail food sales account for rcent of our expenditures and in- e candy sold in gas stations, food candy sold in drugstores and rtment stores, mail order gift s, etc. Much of this stream of is processed grocery items sold ıgh drug and department stores.

taurants, Fast Food

away from home is 35 percent r total expenditure pattern, and ing. It is growing more in terms of volume of food than in share of expenditures because the fast growth part is fast food, which is the least expensive.

Conventional restaurants take in almost 15 percent of our food outlays. Besides supplying food, they also provide a celebrating aspect which is important in our culture. Often the share of the cost going for service and other amenities is more than the cost of the food provided. While this channel may not offer the most economical way to be nourished, it is generally regarded as a pleasant and celebrative event within our culture.

Fast food accounts for 10.5 percent of our food expenditures and possibly



JOSEPH VALBUENA

More than 10 percent of the American food dollar is spent for fast food.

more meals than conventional restaurants. This channel specializes in efficient nourishment but with a minimum emphasis on amenities and celebration. It is a fast-growing alternative serving especially well the households where both spouses work or only one parent is present.

Institutional meals such as hospital, school, or workplace food service represent 1.3 percent of total food expenditures, while vending machines add another 1.2 percent. Vending machines are a growing aspect of a convenience-oriented food market. Other prepared food may include popcorn at the movies, hotdogs at the ball game, or the ice cream bar you buy on the Mall in Washington, D.C. This miscellaneous channel accounts for 7.4 percent of consumer food expenditures.

Through choosing among these channels, consumers adapt to a new pattern of food arrangements and a new way of living. It is not easy to assess advantages or disadvantages of these changes. It does seem appropriate to observe that changes in food patterns are closely related to living patterns.

Factory Preparation

We purchase prepared foods for consumption away from home as noted above, but within the supermarket the extent of preparedness of food products is an important choice. As we seek convenience, a frequent result is that the final food product is prepared in the factory rather than in the kitchen.

This transition affects many things. The final products are often perishable. Grain or flour can be safely stored long periods at moisture content levels below 15 percent or so. Bread, on the other hand, has a high moisture content when fresh, which encourages mold and requires complex packaging. By choosing prepared foods, we usually increase pack-

aging and handling costs and also require use of preservatives.

Other consequences relate to buying processed foods. A few food ingredients may be made into hundreds of different final products. Grandma used to create all of that variety in the kitchen. If the desired variety of foods is developed in the factory, the distribution system has to fuss with our food supply in tiny bits and pieces rather than large flows. Clearly this adds expense. It also destroys the very reliable unit of measure (price per pound) so useful in buying staple foods of the past. What is the unit of measure for Pop Tarts? How do you compare them with Brown 'n Serve rolls?

In addition to the frustration in finding a useful unit of measure, these finished products are in small (usually one-meal oriented) quantities. Unlike buying 50 pounds of flour as Great Grandma did, we find it hardly worthwhile to be a serious price shopper on a package of Pop Tarts. The price per package is small and we are subject to more sales persuasion than if the choice had a significant budget impact. These aspects of the emerging food system illustrate that having more consumer choices is not unambiguously advantageous.

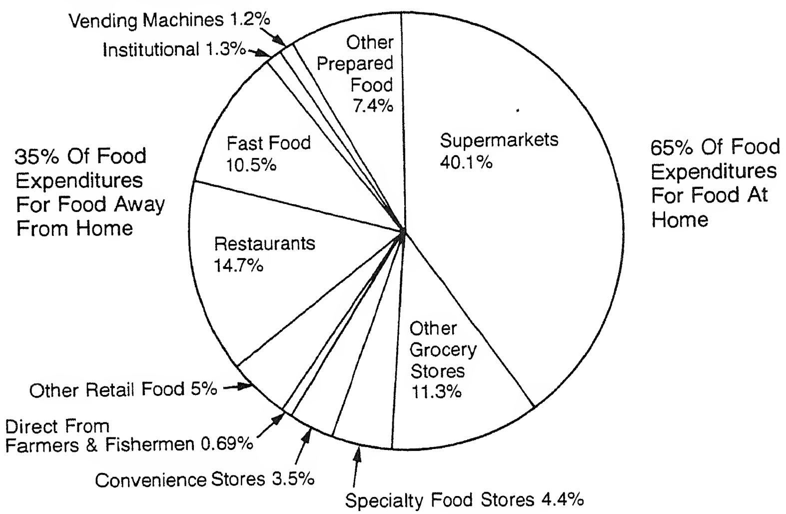
Name, Economy Brands

Another pattern within the supermarket enables consumers to choos processed products which are the focus of a great amount of marketin activity or shun them for simpler economy products. National brands tend to be innovative, interesting, status oriented, and expensive. The are some products where one can't find an alternative to these feature But in most food products where na tionally advertised brands achieve significant market volume, cheape copy products soon follow.

The largest food retailers (the fo chains) are experts at this act. The copy products usually have the re-

Channels of U.S. Food Expenditures, 1980

Source: Manche



USDA

Generic-labeled products are almost always a good value for the money and offer the consumer an alternative to the highly advertised, more expensive brands.

tailer's label or the newer generic label. They are almost always a very good value for the money. Most consumers understand this complex choice pattern and, as a result, economy products limit the power of the highly advertised brands.

Consumer choice patterns are hard to understand and predict unless they can be linked to some pattern of rational behavior. The most significant linking has been in relation to a concept of "money rationality." The economist's theory of consumer behavior identifies a relation between preferences and a budget constraint.

This approach to understanding consumer choices doesn't work very well in the supermarket. There are several reasons. The dividing of the food supply into tens of thousands of choices makes consumer choice very complex and time consuming. Point-of-purchase merchandising stimuli influence our choices. The consumer's pattern of living makes money more available and time more scarce.

As a result of these changes, we must come to expect the consumer to be "time rational" as well as "money rational." We must understand that it isn't worth the effort to be highly informed—item by item. The results of using general "rules of thumb" and habits (generic brands, etc.) take less time and are more satisfactory than shopping patterns that are more analytical.

We must also come to understand that this rational indifference to the tiny price signals on food products makes consumers more subject to influence by advertising and other marketing stimuli. Especially as pertains to new products, the consumer is passive and the food manufacturer active. In this process of economic evolution, we have gained some variety in available choice and lost some consumer sovereignty at the same time.

The emerging food system has provided a basis for our population to be nourished and to significantly adjust our lifestyle. We have chosen convenience and factory-made variety. These choices have brought the need for more developed public initiatives.

Food safety questions are much more complex and troublesome than in times past. Nutritional labeling and other product identification policies have been necessitated by the more complex formulated foods.

Some troublesome questions remain. Big companies advertise highly processed products, while fresh fruits and other unprocessed products rarely are advertised. Does this lead consumer choice patterns in the best direction?

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Zip—Flash, and the Food You Want Is on Its Way

By Dennis R. Henderson

It is wasteful to produce peanuts when the buyers want bananas, costly to ship to Tupelo when the buyers are in Toledo, confusing to ship to Sam when the buyer is Dan, and frivolous to deliver in September when it's needed in December. Marketing is the process by which the right products get to the right persons in the right places at the right time.

The questions of what, who, where, and when continually beg for answers. Complete, accurate and timely market information provides the answers, which help minimize confusion, waste, and costs. Information is the key to efficiency in marketing.

The complexity of providing and obtaining market information is a function of the rate of change in market conditions. Useful information can be obtained through experiences in the market when consumer tastes change slowly, production is relatively stable, and the costs of doing business don't fluctuate very much. But when market conditions change rapidly, costly mistakes often result from relying upon information obtained through past experiences.

Thus, as the speed at which the answers to the what, who, where, when questions change, the importance of systems for the rapid collection, analysis and dissemination of market information increases.

That today's marketplace for food and agricultural products is subject to rapid change needs little elaboration. Soaring energy and transportation costs, marked oscillations in foreign demand, store closings, plant consolidations, inflation, and changes in eating behavior are all factors. As a result, the potential for economic losses and inefficiencies due to poor, incomplete, outdated and/or inaccurate market information is considerable.

Tailored Technology

Fortunately the technology for providing and analyzing market information, for creating knowledge, has literally exploded in recent years.

Modern electronic communications and data processing technology provides the capability to obtain complex and sophisticated market information, instantly tailored to specific user needs. User applications are being developed which allow more accurate and rapid response in the marketplace, thus facilitating efficiency in a rapidly-changing market environment.

We are talking about electronic computers, high speed data transmission, electronic sensing devices, home computers and portable computer terminals, space communications, ultrasonic detection technologies and the like.

Electronic computers are compact and fast. Today's computer the size of a home refrigerator has a greater capacity than the computer of a decade ago that was larger than the

whole kitchen. Computation time is now measured in nanoseconds (one-billionth of a second) and laser beam technology which operates at the speed of light is being developed. Thus, computers can process data very rapidly, creating information that is specific to the needs of individual users.

Equally impressive developments are occurring in the technology for communicating among computers and between computers and people. Telephone lines that a few years ago were limited to transmitting 10 to 20 characters of information per second are now routinely handling more than 10 times that amount. Dedicated data lines can now handle more than 1,000 characters per second in many cases.

Microwave signals relayed by space satellites, which are even faster and offer potential for lower costs, are already in limited use. Fiber optic technology is being developed which can bring the speed of light to communications as well as to data processing.

Computers That Talk

Low cost, portable, easy-to-use computer terminals that allow people to interact with computers are commonplace. Now these connect up with computers through telephones, use typewriter-like keyboards for communicating to computers and printers or TV-like screens to receive information from computers. Some use TV sets as receivers and cost only a few hundred dollars.

Some computers can speak, allowing a telephone to be used as a receiver. Technology is currently being perfected which allows people to tall to computers. Thus a standard telephone becomes a completely interactive computer terminal. Using video displays, computers now give users graphical and pictorial information besides verbal communications.

Also, electronic sensing and detection devices are being developed tha allow computers to obtain accurate information on many things that affect the marketplace, without direct input from people.

One example is space satellite scanning of crop conditions. This ha the potential to provide computer data banks with detailed informatioı on crop acreages, growth conditions and expected yields. Detection of livestock inventories may also be possible.

Other technology is being developed which electronically assesses product quality. Meat quality detection is nearly perfected. Electronic scanning of such things as uniform product codes has automated grocer inventory control and is rapidly tak ing over at the checkout counter.

Indeed, the technological capability exists for creating useful and relevant market knowledge in a rapidly changing environment, and for facilitating the ability of people to act upon that information.

To date, applications have been made largely on a piecemeal basis. The potential benefits of a more systematic development are many and impressive. However, these systems can be expensive to develop and may require use of some safeguards to assure accuracy and integrity. Furthermore, the benefits often cannot be fully realized until such systems are widely accepted by users.

Many applications of electronic data processing and communicati to market information problems a currently in use and others can ea ily be visualized. The following vignettes portray a combination o existing and potential application

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Bumbo's No Dumbo

Bumbo's is a hypothetical firm with a nationwide chain of restaurants. They want to build warehouses to supply restaurants in a seven-State region.

Their objective is to select the number and the location of warehouses that will result in the most efficient, lowest cost transportation of food from their basic suppliers to their restaurants, while at the same time minimize storage costs. A computer is used to analyze relevant information and assist in decision making.

Bumbo's recognizes that there are relatively few fixed factors to be considered and a host of uncertainties. They believe the network of interstate highways and other major thoroughfares is unlikely to change much in the years ahead.

They also believe that trucks will be their major type of transportation. However, they recognize that freight rates are likely to increase rapidly as energy costs and industry regulations change.

Furthermore, they want to consider several additional variables, including:

1) Different basic suppliers at various locations around the country, 2) Addition of some new restaurtants in future years, along with possible closing of some existing restaurants, 3) Changes in eating habits which would result in menu changes and thus a somewhat different product mix, 4) Projected shifts in food packaging that will extend shelf life and decrease in-restaurant preparation time, and 5) Increases in per-restaurant sales as eating-out continues to grow in popularity.

To resolve their warehouse questions, Bumbo's uses a well developed computer technique called spatial equilibrium analysis. Once the computer digests information on highway, existing and

potential restaurant and supplier locations, costs of shipping, warehouse building and operating costs, and other relevant variables, it can rapidly determine the number of warehouses needed in the region for the most efficient movement of products. And it can pinpoint their locations.

Through another computerized technique, called parameterization, the computer can demonstrate how sensitive its warehouse number/location answer is to changes in each of the variables considered, including transportation costs, product sales and other uncertainties.

Generating marketing information with this type of locational analysis is currently a well-accepted practice among many firms involved in marketing food and agricultural products.

Farmer McBeef

Direct sale of farm products to consumers often has considerable appeal both to farmers who believe they can increase their income and to consumers who feel they can obtain fresher products at competitive prices.

Complexities include knowing where sales or purchase opportunities can be found and making reliable price comparisons.

Imagine a couple of suburban consumers, each of whom wants to buy a side of beef to put into his home freezer. A cattle producer in a nearby county has steers ready for market. And a small meatpacker on the urban fringe has some excess butchering capacity.

All the elements are here for a direct, custom processed sale of beef from the farmer to the town dwellers—except for the information necessary to bring everyone together.

Now imagine a computer system that accepts, stores, sorts, compiles, matches and supplies information on farmers who have beef animals for sale, meatpackers with custom slaughtering capacity, and consumers who want to buy freezer beef.

The farmer might call his county extension agent with information on cattle he has to sell, their quality, when they are available, his asking price, and so on. The county agent enters that information in a computer using a remote terminal in his office.

The meatpacker can mail a notice of his custom slaughtering capabilities and charges directly to the computer service, where the information is entered into the computer's memory.

The consumers stop by a computer terminal in a local shopping

center or store to inquire about buying opportunities and costs, or to enter a desire to buy into the computer's memory.

With similar information compiled from many people, the computer can quickly respond to each inquiry with information on selling or buying opportunities and comparative prices and costs. Basically, the computer matches buyers and sellers by providing users with "best trading opportunity" information, and eliminates much of the cost of individual searches and missed opportunities.

A system like this for beef has been operated on a pilot basis by the Kentucky extension service and similar systems have been designed elsewhere, primarily for fresh fruits and vegetables.

Mini the Computer

In developing a marketing strategy, farmers must consider a large array of factors. These include information on immediate marketing opportunities, prices being paid by buyers at different locations, quality premiums and/or discounts, and transportation costs by various shipping methods to alternative buyers.

Also, to be considered are storage costs and availability of warehouse capacity, probabilities of product degradation in storage and/or in transit, production costs, opportunities to contract for future delivery, prices being offered for future delivery, competition from other sellers, overall levels of product availabililty and use, current and expected developments in world markets, and futures market prices.

Additionally, the farmer may have several objectives he is trying to achieve. Some may be inconsistent with others.

For example, achieving the highest price may not be consistent with minimizing the risk of selling at a loss. Or maximizing profits may not coincide with the objectives of maintaining long-term sales oportunities, reducing tax exposure, or achieving a targeted rate of return on investment.

An on-farm microcomputer, when properly programmed and complemented with available information, provides the farmer with a powerful tool for analyzing marketing oportunities and examining trade-offs between different strategies and objectives.

The computer can consider a myriad of factors specific to an individual farm business—such as the relationship between the farmer's grain storage capacity, storage costs, quality degradation, and historic and/or expected time-related price differentials—and determine the best combination of all such factors in terms of meeting any number of specified goals.

Much information not generated within the farm business itself can be obtained directly from computerized data banks around the country and from other electronic sources.

For example, the farm computer might access, by telephone, a distant data bank that includes historic and current futures market prices and spot market prices at several locations. Another data bank accessed provides information on commercial storage capacities and costs, location-specific shipping rates and other handling costs. Still a third bank gives crop condition information gathered by space satellites.

The computer can obtain relevant information on the farm itself from the data already stored in the computer's memory from its recordkeeping and accounting activities.

The computer can be programmed to compare alternative marketing strategies, select the one that best meets the farmer's goals, and even implement parts of the selected plan such as issuing a "sell" command to a commodity broker. Some farmers already have microcomputers that can do parts of this task, and computer capability is rapidly being developed to bring about more.

Buying Groceries Via TV

Think of a homemaker doing grocery shopping on a TV set. The TV is connected to a keyboard and, through a telephone, to computerized catalogs of food and other products sold at various stores.

By depressing a key on the keyboard that corresponds with, say, Colossal City Supermarket, the total offerings of that vendor can be flashed on the TV screen product by product.

Keying in other selections can call forth listings on specific products and even on specified brands. Nutritional and other user information also can be obtained. Through other keys, similar offerings from other stores may be displayed.

With a few simple instructions to the computer which controls this system, the homemaker can compile a file of items being considered for purchase. The file can be displayed on the TV screen, showing comparative information by vendor, including both product and unit prices.

From this listing, the shopper can select the vendor that offers the desired list of products at the lowest total cost, or divide the list among bargains by different sellers in order to minimize total expenditures.

Further refinements in the system could enable the homemaker to instruct the computer to actually place orders for the selected

items once final choices are made. Also, automatic shopping could be accomplished whereby the computer would alert the shopper of price and/or product changes that affect the choice of a standard list of goods, and otherwise automatically order preselected goods on a use-based time schedule.

Technology for this type of in-home food shopping currently exists. While major applications for grocery buying are yet to be developed, similar systems are already in use for obtaining comparative food price information in certain metropolitan areas. Some national dry goods merchants are establishing electronic catalogs as replacements for printed versions.

Hoggish Dilemma

Consider a hog producer in Illinois, producing about 100 head of high quality market hogs every two weeks or so. Assume there is a meatpacker about 30 miles away who will purchase his hogs delivered to the plant, at "25-75 cents over the market" as represented by the packer's posted purchase price for that day, "depending upon quality."

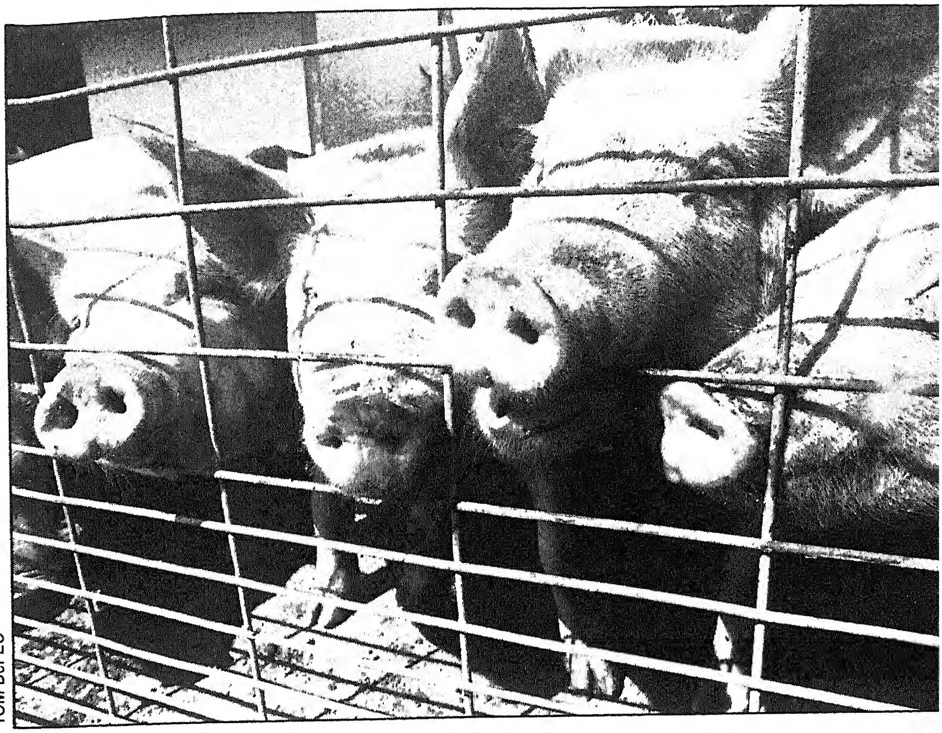
Assume a hog dealer has a buying station about 15 miles away who will purchase hogs on private treaty. That is, at a price negotiated between the dealer and the farmer. Assume there are no other hog buyers within 60 miles.

Now, consider the farmer's dilemma. He can deliver his hogs to either the buying station or the packing plant and hope he receives a "fair" price. Of course, he loses much of his bargaining strength once the hogs are delivered, as it is expensive to reload and take them somewhere else.

Or he can phone each of the buyers and get a price quote before he ships, and compare those quotes with news reports on hog prices. Of course, the buyers are only estimating the quality and probably the weight of his hogs. And the news reports are for "average" quality hogs as reported by unknown buyers and may, but probably don't, reflect a realistic selling opportunity for this farmer.

As a third possibility, the farmer can use a computer terminal to access a large-scale computerized auction that is also being used by several other farmers and distant buyers. He uses an electronic scanner in his hog barn to determine the quality and the weight of his hogs.

The computer then tells him how many similar and dissimilar hogs have been sold today and historically, at what prices, to whom



TOM DeFEO

and from what locations, how many are currently available for sale, and even how many are likely to become available in the future based upon electronic surveys of hog production. Using this information the computer estimates the most likely market price for his hogs.

If the farmer chooses, he can instruct the computer to sell his hogs to the highest bidder, for either current or future delivery. The computer flashes his sales offering to the computer terminals of numerous buyers, solicits bids, and awards the sale to the highest bidder (assuming, of course, that the high bid meets or exceeds the farmer's minimum asking price). The computer automatically adjusts buying and selling prices for shipping costs and issues delivery instructions, invoices, checks, and other market clearing information.

Electronic trading systems that perform many of these marketing functions are currently in commercial operation for eggs, and experimental systems have been used for selling feeder cattle, slaughter hogs and market lambs. Technology for this full array of activities exists and applications in actual market situations are steadily progressing.

Marketing's Frailties, Faults, and Frustrations

By B. Marion and J. von Elbe

John was discouraged. He and his family had developed a new type of cereal. Neighbors and friends on whom they had tested the product raved about it. It was a flavorful, nutritious, whole grain cereal and relatively low in price. A local grocery store had done well in selling the cereal.

John thought it was time to expand, and began contacting chain stores and grocery wholesale buyers in nearby metropolitan areas. Although consumer reactions had been positive toward his product, chain and wholesale buyers were consistently negative. One of their first questions was how much advertising was planned to promote the product. Cereals are sold by advertising, he was told.

The chain buyers were also concerned about the volume he could supply. They were not interested unless they could carry it in all their stores. Besides, in selling through a broader distribution network, the whole grain nature of the cereal would result in problems of rancidity unless a preservative was added. Turnover would not be fast as in John's local grocery store.

John got the feeling that most of the buyers just didn't want to bother. With shelf space at a premium, why should they fiddle around with a new product from a small family operation when the major cereal companies kept their retail shelves full?

So John went home with a new image of the U.S. food marketing system. He had always been told that in the U.S. market economy, consumers dictate what is produced by their behavior in the marketplace. He now realized that while this ultimately may be true—a lot of factors influence consumer decisions in choosing among products. Firms in the marketing system have a substantial influence over that choice through advertising and the products they decide to produce or stock. Providing a better cereal at a lower price doesn't do much good if consumers get no chance to buy it.

Oriented to Mass Market

The U.S. food marketing system has become highly industrialized. Large food manufacturers and food retailers, primarily oriented toward the mass market, are the main sources of power and control in the system. Movement of many products through the system is orchestrated by contracts and standing agreements.

The characteristics described have brought some of the benefits talked about in other chapters. However, they have also resulted in roadblocks and limitations—the focus of this chapter.

As John found out, opportunities for small companies fell off as the food marketing system became industrialized. Small farmers now have difficulties finding buyers for their products and often are penalized price-wise. Small food manufacturers find it hard to compete with big

With the growing industrialization of the food marketing system, competition in many markets and industries has declined.

manufacturers and to supply large retailers.

The number and market share of independent retailers and restaurants has dropped. Thus, opportunities for entrepreneurs with ideas to enter the food system have shrunk.

With the growing industrialization of the food system, competition in many markets and industries declined. For example, four companies account for about 90 percent of the soft drinks sold in the United States. The leading four cereal manufacturers have over 80 percent of ready-to-eat cereal sales. Three companies produce nearly 90 percent of the cake mixes sold.

In food retailing, the four largest food chains in Denver, Washington, D.C., and many smaller markets account for about 90 percent of the supermarket business. Metropolitan areas such as Cincinnati and Macon, Ga., are clearly dominated by one supermarket chain.

Considerable research tells us that when relatively few firms hold most of the sales in a market or industry, competition deteriorates, prices tend to rise, and efficiency and progressiveness fall off.

Although competition is inadequate in several parts of the food system, it is not a universal problem. But lack of competition is most common and has the most serious consequences in food industries with highly advertised products— and where private label or generic products are unimportant.

Conglomerates

For our purposes, conglomerates are companies operating in two or more industries. Hence, General Foods, although primarily a food company,

is a conglomerate since it functions in several food manufacturing industries (cereals, coffee, frozen foods, dog food) as well as in the restaurant industry.

Few people realize the size or degree of involvement of conglomerates in the food system. The degree of diversification/conglomeration has also increased, particularly via mergers. For example:

- Greyhound owns Armour
- R.J. Reynolds owns Del Monte
- Philip Morris owns Miller Brewing
- Nestles owns Libby and Stouffers
- General Foods owns Oscar Mayer
- Pillsbury owns Green Giant

These are but a few of the mergers and acquisitions that have occurred during the last two decades. Through a series of mergers, Beatrice Foods Co. now produces such diverse products as Meadow Gold milk and ice cream, La Choy Chinese foods, Sunbeam bread, Clark candy bars, Eckrich meats, Samsonite luggage, Airstream trailers and Hart sports equipment.

Conglomerates can compete in ways not available to the more specialized companies. Tremendous total resources are often at their disposal, allowing them to outspend, outlose and outlast more specialized companies.

When two large conglomerates engage in a competitive dogfight, as General Foods and Procter & Gamble did in a contest for the Eastern U.S. coffee business, more specialized companies often find themselves first on the sidelines—unable to give battle—and then out of business.

Research shows that a conglomerate acquisition of a food manufacturing company is generally followed by a significant increase in advertising. Up to now the antitrust agencies have never challenged "predatory" advertising—even though the consequences are similar to predatory pricing, which is illegal.

Consumers Swayed

Food products are among the most advertised products in our U.S. economy. When skillfully done, advertising obviously influences consumer choice of brands even if no physical differences exist.

For example, consumers have been willing to pay 30 to 50 percent more for ReaLemon than for identical concentrated lemon juice under another brand. Many private label products compare in quality with advertised brands and sell for much less—yet a substantial number of consumers continue to buy advertised brands.

Intelligently choosing between alternative products in the American economy is time-consuming and difficult; many consumers choose to rely on brand names in making those choices. For this reason, large firms with the knowhow and finances to effectively use advertising enjoy a great advantage over smaller companies. Profits tend to be far bigger in industries with heavy advertising, such as soft drinks and ready-to-eat cereals.

Of long run concern is the effect of advertising on consumption patterns and ultimately on nutrition. If heavy advertising of soft drinks, for example, results in consumption shifting from milk and toward soft drinks, what are the implications for nutrition?

Highly processed products tend to e more heavily advertised than asic products. Many nutritionists onsider highly processed items as utritionally inferior to the more asic ones.

Thin Side of the Coin

As more exchange in the food system occurs via contracts and vertical integration (ownership by a firm of one or more of its suppliers or customers), declining portions of some products are sold in "open markets."

"Formula pricing"—where the product price is determined by a base price in another market—is used widely. For example, the vast majority of cheese in the United States is formula priced using the National Cheese Exchange as a base. The latter accounts for less than 1 percent of cheese sold in the United States. Hence a market price for less than 1 percent of the cheese is used to price the remaining 99 percent.

"Thin markets" of this type may perform well, and the available evidence indicates that is true of the National Cheese Exchange. Yet opportunities for manipulation and inaccurate price signals are greater than with markets representing a greater share of total volume.

Thin markets or price reports based upon a small share of total volume occur in butter, beef, eggs, sugar and in certain fruits and vegetables.

Impediments to Technology

Some technologies require cooperation at more than one stage in the food system. For instance, the universal product code and electronic scanning in supermarkets depend upon food manufacturing and food retailing companies working closely together. Unfortunately, manufacturers may wait for retailers and vice versa, resulting in substantial delays in implementing improved technology. Some of the greatest potential gains in efficiency and coordination require cooperation throughout the food system.

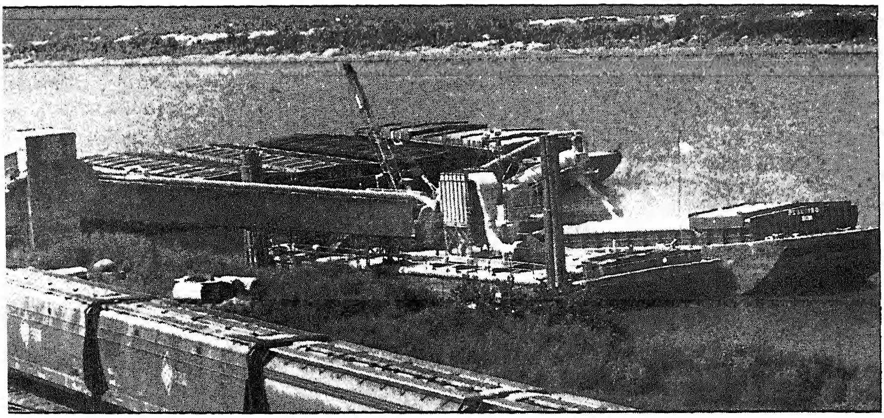
New technology may be actively opposed by participants in the system. For example, electronic trading of some commodities holds the potential for broadening markets, increasing the competition and increasing market information. However, electronic markets may eliminate or reduce the need for certain participants, who may actively oppose such markets.

Moderate sized firms in industries with healthy competition appear to be the most progressive in implementing new ideas and technology. Hence, industries with ineffective competition tend to be slower in adopting new technology; likewise for small companies.

Transportation and storage facilities and rates have a strong effect upon the location of production and processing and the smoothness with which the system operates.

The U.S. transportation system is in transition as railroads, a major carrier of agricultural products, are struggling to adapt and survive. Through mergers and bankruptcies, the 40 Class I rail carriers are expected to decline to about 10 by 1990.

As railroads attempt to adjust to shifts in the location of agricultural production and competition from trucks and barges, continued rail abandonment—particularly in the Midwest and East—can be expected.



The U.S. transportation system, so vital to marketing, is in transition as railroads struggle to adapt and survive.

This will impose hardships on individual businesses and communities affected but may be essential for railroads to survive.

One of the competitive advantages of barges has been free access to waterways and locks. However, if proposals are implemented to recover the costs of operating locks and waterways, the competitive balance would shift back towards railroads.

Given the large and inflexible investment in rail lines, waterways, and rail or barge equipment, the major challenge facing the transportation system is in adjusting with sufficient speed to changes in the location of production and markets, and to public policy shifts.

"Natural" Foods

Considerable misunderstanding has emerged during the last 15 years over food processing, and particularly the use of additives and preservatives. The words "natural," "no preservatives" and "no artificial additives" are embraced, while anything that smacks of chemical treatment is viewed with alarm.

Because of consumer interest about nutrients and additives, companies manufacturing food products have also become concerned. However, worries over additives and preservatives are in some cases overdrawn or misdirected and pose roadblocks for the food system.

A natural product, just because it is "natural," is not necessarily safe. Some plants used as foods contain naturally occurring toxicants. They occur in minute amounts which our bodies can tolerate. Still, if subjected to the same FDA screening as food additives, these plants would never be permitted for use.

Food, both plant and animal, when harvested immediately undergoes changes. Meat will spoil rapidly if not handled properly. Green peas continue their metabolism after harvest, building starch; their textural quality will fall off if they are not processed immediately. Processing attempts to retard or minimize such changes. Our industrialized food system and the expectations of consumers for products year-round require processing of many foods.

The techniques are many. Foods can be preserved by removing heat (freezing) or adding it (canning), removing water (concentration or dehydration), adding chemical preservatives (sugar, salt), removing microorganisms or keeping microorganisms out (asepsis), controlling the growth and types of microorganisms (fermentation), and maintaining conditions limiting the growth of microorganisms or the metabolic rate of plant tissue (packaging, atmospheric storage).

None of these ways is perfect. All cause some alterations in the food. Any method available brings about changes in one or all food quality attributes (flavor, color, texture, nutrition).

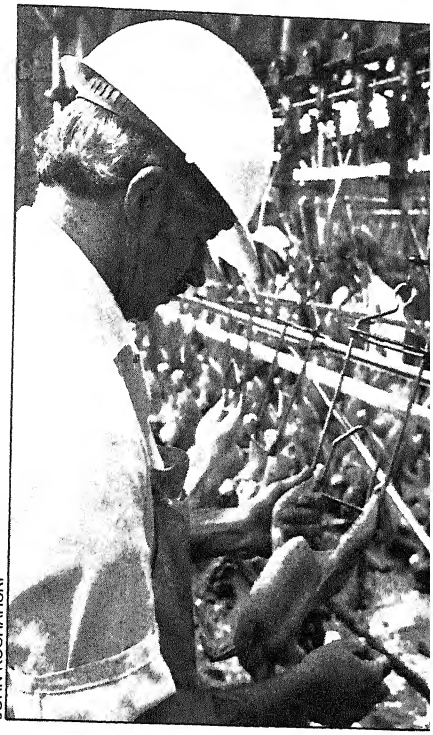
Help From Additives

Some changes have been minimized through approved additives. Additives can prevent destruction of products by microorganisms, changes in flavor, texture or color, and nutritional alterations.

This practice has sometimes been criticized because additives are chemicals. Indeed they are, but so are foods. In fact, all of our foods are an extremely complex mixture of chemicals.

In most cases, dangers posed by additives are far less than those that would exist without them. For example, the products of fat oxidation are a far greater health hazard, in our opinion, than adding a fractional percent of a tested and approved additive to prevent such oxidation.

Given the present food system, additives are needed for an adequate food supply and the variety of products to which consumers have become accustomed. To do without food additives would mean a return to food preparation in the kitchen with limited availability of products.



JOHN KUCHARSKI

Regulations in the food industry may need adjustments, but seldom should be abandoned. For instance, poultry plant inspection laws may be a constraint, particularly to small plants, but provide assurance to consumers that products are slaughtered and processed in sanitary facilities.

Thousands of additives are recognized by the Food and Drug Administration. Any additives found to pose health problems are likely to be a tiny percentage of that total.

This is not to say that those who choose to avoid additives in their foods—to the extent they can—are completely without reason. The consumption of salt is a good example.

Labeling Needed

Used for years as a preservative and seasoning, salt now has been found to be related to high blood pressure and hypertension. For the increasing number of Americans with these problems, being able to select food on the basis of salt content is extremely important.

Unfortunately, labels on most food products do not indicate the amount of salt included. A relatively simple change in labeling would remove this obstacle for those worried about hypertension and allow consumers to demonstrate their preferences for different salt levels through their purchases. The level of sugar or carbohydrates in food products should also be considered for inclusion on labels.

Food additives play an essential role in our industrialized food system. While consumers should be informed about the content of their food, a blanket indictment of additives and preservatives is unwarranted.

It is fashionable to favor deregulation of many aspects of our economy. In the food system, adjustments in regulations are often more appropriate than total abandonment of regulations. Nearly all regulations benefit some and cost others. "One man's tonic is another man's poison."

Some regulations, such as those enforced by the Food and Drug Administration or the Environmental Protection Agency, are aimed at protecting the broad public interest. Others such as import restrictions on certain products are primarily aimed at protecting a special interest group—the producers and manufacturers of the products.

To define those regulations or policies that are bottlenecks or constraints, one must identify to whom they are constraints. Meat and poultry plant inspection laws are a constraint to small plants particularly, but provide assurance to the public at large that products are slaughtered and processed in acceptably sanitary facilities.

Competition

The least burdensome regulation that will achieve the desired end is generally preferred. Thus, regulations to encourage and protect competition are normally preferred to direct control of prices and profits.

The drop in competition in several areas of the food system is a cause of concern. Antitrust laws, as enforced, have failed to restore effective competition, once it has been lost. The antitrust laws have been successful primarily as a holding action—helping to preserve competition in industries that are reasonably competitive.

However, present law does not allow antitrust agencies to effectively challenge industries where the lack of competition results in substantial overcharges to consumers. The large majority of conglomerate mergers are also relatively immune from existing antitrust law. If competition is to be restored in those industries where it is now weak, new laws probably will be required.

The number of regulations to protect consumers has increased significantly during the last 20 years. Many have brought benefits to consumers—and in some cases to the food industry. At the same time, regulations also pose a burden and cost

to the industry. In some cases alternative types of regulations could accomplish the stated objective with less burden and/or cost to the food system.

"Drained Weight"

The recent proposal of "drained weight" labeling is an example. On the surface it seems plausible that each label of a canned item (fruits and vegetables) carry a weight declaration indicating the solid content in that can. But it's not that easy.

The drained weight of a canned product is determined by emptying the contents of a market ready container upon a mesh screen. The product is allowed to drain for two minutes and then the solid portion is weighed.

Drained weight can only be determined after the can is sealed and sterilized. Therefore, determining drained weight requires destructive sampling, the loss of product and container. This would increase production cost and ultimately cost to the consumer.

The U.S. canning industry has suggested "fill weight" declaration as an alternative. Fill weight is the amount of solid product placed in the can. It is thus comparable to drained except it weighs the solid portion before rather than after canning. Usefulness of fill weight to consumers would be very similar to drained weight. Fill weight does not require destruction of valuable food and would be less costly to both consumers and the industry.

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Joachim von Elbe is Professor of Food Science at the University.

Further Reading:

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Young Adults, Other Food Industry Challenges

By H.S. Ricker and W.H. Tallent

Our food marketing system is a complex arrangement of firms that try to balance the needs and the wants of both farmers and consumers.

Farmers expect that the marketplace will take all they can produce whenever they are ready to sell. Consumers take it for granted that the type of food they want will be there when they want it and at reasonable prices.

It is a testimonial to our food system and its many participants that their expectations are so high. A challenge for the future is our ability to continue to live up to these expectations. Some people look to the future and say it may not be possible, but we will discuss some examples of the changes taking place and the challenges they offer in marketing.

By the end of this decade a third of our population will be young adults. Predictions are that the average household will decrease to 2.4 persons from today's 2.8, and in more than half of the new households established during the 80's both spouses will be employed. This means increased demand for more convenience foods.

Busy working homemakers—whether parents, couples, or singles, will want more food products that are quick and easy to prepare: just drop the package in boiling water for five minutes, or warm to serve in the microwave oven. And they will want more food packaged in single or double servings.

Sins of the System

We do not have a perfect marketir system. Although the marvel of th world, it is not automatic. Instabilities arise from depending upon human judgments made by indepe dent individuals, the vagaries of weather, livestock replenishment c cles, supply, demand, and related fluctuating prices.

Farmers are critical of marketir margins—the difference between what they get when they sell thei commodity and what the consume pays for it. Consumers complain about the high price of food they b even though it appears to be a bar gain in comparison with other developed countries.

While these may be time-honore complaints, the fact is that about two-thirds of the consumer's food d lar goes for marketing costs. An added dilemma is that neither the farmers nor consumers know whor to blame for the wide marketing margins.

If the marketing system had bee evaluated, examined, and researcl like the production system, we wou be better able to identify specific causes and possibly resolve them. But understanding and improving the system is a challenge for the f ture that may be difficult to meet given limited financial resources a other national priorities.

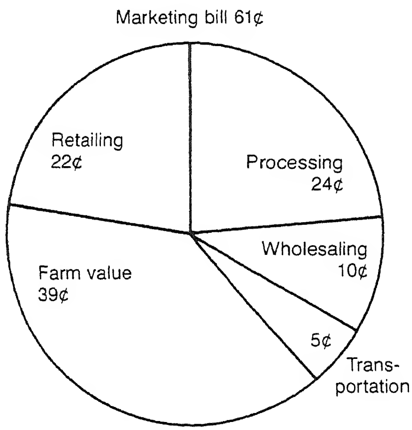
Nutrition and Health

Another challenge to the marketing system is the growing sophistication of public attitudes regarding nutrition and health.

Controversy about specific cause and effect relationships like cholesterol and heart disease notwithstanding, there is an emerging consensus among health professionals that what we eat does affect how long and how well we live.

Spectacular advances against overt vitamin and mineral deficiency syndromes and infectious diseases were the major medical accomplishments of past decades. Nutrition as a more subtle and general determinant of health and longevity is the next frontier. Ever better educated and informed consumers are becoming more and more aware of this, and it is increasingly influencing their food choices. The old adage in food marketing circles that "you can't sell nutrition" is no longer true.

The Food Dollar:
Processing and Distribution Costs Exceed Farm Value



Technology exists or is on the horizon to enable the food marketing system to respond to consumer preferences for more convenient products with better nutritional quality.

Among innovations are better preservation and flexible packaging. The two go hand in hand.

Flexible packages can readily be designed to increase the efficiency of preservation treatment. With thin profiles and large surface areas, for example, the preservation process can be speeded up.

More effective preservation in turn means better storability, thereby enhancing the usefulness of flexible packaging for ready to eat and warm and serve foods.

Standardizing

At the same time flexible packaging could also help pave the way for major changes in the handling of food products. By eliminating the need for some of the cans and bottles, the food manufacturing industry might be encouraged to move toward adopting a few standard sized shipping containers.

In one warehouse stocking 5,000 grocery items, there were 2,587 different sizes of shipping containers. Variable sized containers require special handling and result in ineffi-

LARRY RANA

Today's consumers are more aware of the nutritional value of food and it reflects in their food choices.

cient use of space in warehouses, as components of mixed loads in trucks, and in the retail stores.

The challenge is that one size may be efficient for a manufacturer but inefficient for firms handling the products because other manufacturers use different sizes.

Examples of specific new developments in preservation and flexible packaging are respectively irradiation and the retortable pouch. Irradiation has been described by Nobel laureate Willard F. Libby as "... the most important forward step in food processing since canning came into commercial use in the early 1880's".

Experiments to obtain data in support of regulatory clearance for widespread use of irradiation for food preservation are presently being conducted by the U.S. Department of Agriculture (USDA).

Pouch Pros and Cons

The retortable pouch is a heat tolerant flexible container designed to achieve a combination of the keeping quality of canned foods with the flavor advantages of frozen foods. Its contents can either be pasteurized or sterilized in the package or through a combination of pre-treatment and aseptic filling.

To heat to serving temperature, the consumer need merely drop the package in boiling water for about five minutes.

One limitation to the flexible or retortable packaging is that current technology will not allow it to be filled as quickly or efficiently as cans, and this slows adoption. Once a faster filling process is developed, opportunities for this innovation will be greater. The potential cost savings will be tremendous in our competitive environment and should gradually be passed along to consumers.

Also new in sterilization technology are high temperature/short time (HTST) and ultra-high temperature (UHT) processes. They exploit the fact that bacteria are killed faster than flavor and nutrients are affected as temperatures of food products rise.

For example, at approximately 140° C., treatment for one second kills harmful bacteria with negligible effect on milk constituents. Having overcome the flavor problems associated with sterilized milk, firms are currently building plants to market this product in aseptic cartons that need no refrigeration.

Quality Control

Enabling the food industry to take maximum advantage of new developments like HTST process is a revolution in analytical methodology for quality control. Advanced scientific instruments are now available and soon will be commonplace that can measure trace constituents at the parts per billion (ppb) level routinely.

Such powerful analytical tools will make it possible to optimize food processing. The industry will be able to achieve maximum destruction or avoidance of unwanted constituents with a minimum loss of valuable nutrients such as vitamins and minerals.

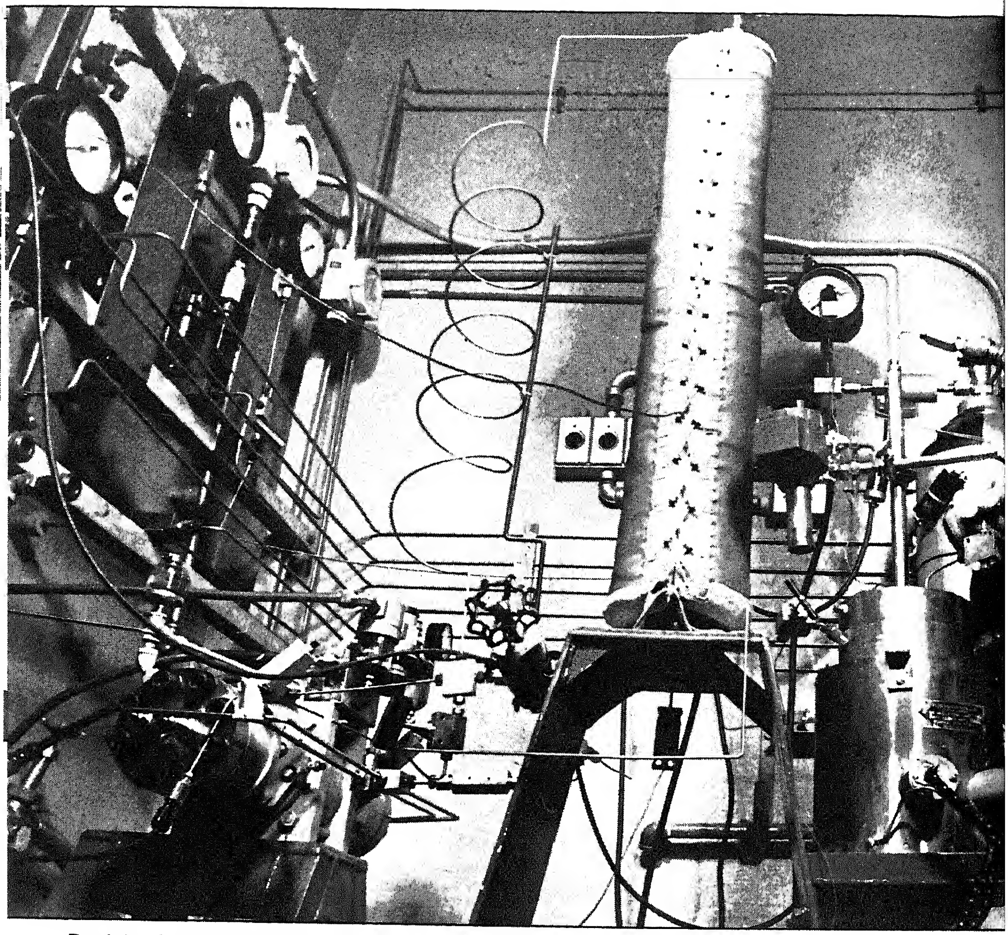
In the mid-1970's a scare about decaffeinated instant coffee made headlines and received wide coverage in the network evening news on TV. The uproar was over residual traces of a chlorinated hydrocarbon used to remove caffein from coffee beans. In high doses this solvent reportedly had induced liver cancer in mice.

Companies voluntarily stopped using the solvent in July 1975 but there is much interest in a revolutionary new process. Instead of washing the coffee bean with a solvent that could leave an objectionable residue, *supercritical* carbon dioxide is used as the extractant to remove the caffein.

Supercritical means the carbon dioxide is maintained at a temperature and pressure so that it behaves partly as a gas and partly as a liquid. It has the penetrating properties of a gas and the density of a liquid. After the coffee is removed from the extractor, any residual carbon dioxide simply evaporates. And even if a trace does remain, it is completely harmless.

This novel concept has potential for much wider application in food processing. For instance, research is now underway in USDA on use of supercritical carbon dioxide to extract oil from soybeans.

Advantages of this technique could lead to improved quality in both the extracted oil and the meal left behind that would carry over into derived consumer products. Soybean oil is used to make margarine, cooking oil, and salad oil. Most soybean meal is used for livestock and poultry feed, but some of it is converted into vegetable protein products for human consumption.



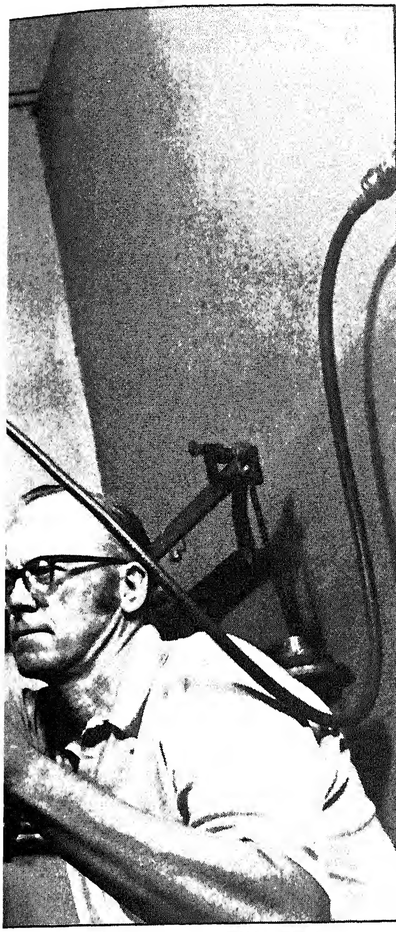
Dr. John Freidrich, USDA scientist, checks equipment before running test on extracting oil from soybeans using supercritical carbon dioxide.

New Roles for Enzymes

Enzymes are biological catalysts. Actually, use of them to modify foods is not all that new. Its oldest form is fermentation, which has been used for centuries to make buttermilk, cheese, pickles, sauerkraut, and tempeh (from soybean), to cite just a few examples.

Application of enzyme preparations separated from the organisms producing them is also well known to us in the use of papain as a meat tenderizer.

These familiar enzymatic processes serve the purposes of preservation, flavor enhancement, and desirable texture and solubility changes. They may be the forerunners of the use of purified enzymes in efficient continuous operations. These could achieve better balance of amino acids in proteins, improve stability and increase polyunsaturation in fats, en-


LINDA HANSON

hance carbohydrate digestibility and modify food fibers, or remove anti-nutritional factors from foods.

Bioregulators, using natural plant hormones, have been found to retard ripening of some fruits, vegetables, and floral products. The ability to extend storage life of certain perishable products with this technique may have dramatic effects in extending seasons and expanding markets. For some of these products the need for refrigeration is reduced, suggesting the possibility of energy savings as well.

Productivity Dip

The food marketing industry and specifically the retail and food service areas have been experiencing declines in productivity in recent years. Productivity growth, meaning output (usually sales) per employee hour, actually decreased in these industries with an average annual decline of 1.0 percent from the early to late 1970's.

When productivity rises, rates of food price increases due to inflation or other cost factors can be held down somewhat due to the increase in marketing efficiency. But when productivity falls, the greater costs of doing business are passed on to consumers in the form of higher food prices.

Declines in productivity in food marketing represent a turnaround from the era of the 1950's and early 1960's when there was a considerable period of growth and a lot of research work undertaken to improve productivity. The late 1970's reflect a period of slower growth and the results of less research. A challenge for the future will be to find ways to develop the technology that will improve food marketing productivity.

There are several opportunities for holding down food costs, but a few examples will suffice. They include: 1) develop substitutes or new food products, 2) utilize waste byproducts, and 3) expand the use of electronics in food marketing.

Sugar represents a good example to illustrate the development of substitutes. In 1974, the price of sucrose

several influences undoubtedly converged to cause this price explosion, general lack of availability of a suitable substitute may have been a contributing factor.

With relatively little fanfare, some corn milling companies had been developing enzyme technology to convert starch to "high fructose corn syrup" (HFCS), a product just as sweet and flavor enhancing as sucrose. In 1974-75, food and beverage firms turned to the lower cost sweetener in droves, with the result that suppliers had to allocate it.

If this substitute had not been available, the inflated sugar price would surely have been passed on to other food prices, probably with a multiplier effect.

ing use of processing byproducts.

The first gasohol marketed in Illinois in 1977-78 was a blend of 90 percent lead-free gasoline and 10 percent alcohol produced by fermenting byproduct whey from the Wisconsin cheese industry. A new sunflower seed processing plant in the upper Midwest burns the seed hulls and thereby generates more energy than the plant uses "by quite a lot," according to a vice president of the company.

There are also innovative ways to turn byproducts into additonal food supplies such as in the millions of tons of residue left from the manufacture of tomato juice and concentrated products, including catsup, paste, soup, and puree. A major part

Electronic computers are already helping food marketing firms control production operations and may play an important role in commodity trading in the future.

f the residue is tomato seeds. Experimental data indicate these seeds can be processed to yield valuable edible oil and protein products.

Many similar examples could be cited. Even carbon dioxide generated n fermentations can be turned back into food. By photosynthesis, nature converts this gas plus water into carbohydrates and oxygen. The principal producer of alcohol for use in gasohol is evaluating use of byproduct carbon dioxide for hydroponic production of fresh vegetables in greenhouses adjacent to its fermentation plants.

Computers have been in use for several years, but were used primarily for accounting functions, and, in a few instances to control production operations. With the expanded capacity of mini-computers, rapid adoption of electronic scanning and improvements in software packages, all types of food marketing firms are looking at innovative ways to apply the technology.

Lacking objective analyses, a real danger is that many firms will buy more computer capability then they will ever need, adding to their costs of business. In fact, a real challenge will be for them to determine what information they really need and to buy or lease accordingly. That word of concern aside, let's briefly look at some potential applications of computer technology on the horizon.

Enter the Robot

Many marketing activities, especially the physical handling processes, are repetitive or routine. At the same time many of the tasks are also complex (for example, handling the many sizes and shapes of packages), making automation difficult and expensive. Recent developments in robot technology, and declining real costs of the equipment, make it likely that robots will find many uses in the future—and especially in food warehouses.

The concept of electronic commodity trading is appealing and currently being evaluated by USDA. It applies recent advances in computer technology to some important problems in markets for agricultural products.

Electronic markets separate two distinct but often combined market functions: 1) negotiating the trade, and 2) physical transfer of the product from seller to buyer.

Through electronic communication technologies, offers to sell may be listed for potential buyers at distant locations. If the buyer is interested in the seller's offer, he then is able to negotiate directly for the sale price and shipping arrangements.

Electronic communication allows more buyers to participate and helps create the highly competitive market necessary for pricing accuracy. Decentralizing the physical exchange of the commodity eliminates much of the costly and inefficient process of assembling buyers, sellers, and products at a single exchange point for possible sale.

Electronic trading has been developed and is being experimented with for several commodities—notably eggs, slaughter hogs, feeder pigs, lambs, cows, feeder cattle, and wholesale meat.

TV for Market News

Electronic communication is also being used for the exchange of market news information about the sale

of products at major markets. Some 140 market news offices throughout the country develop their reports and relay them to a computerized message switcher in USDA that consolidates and relays the information to subscribers.

USDA is exploring procedures to reach farmers and other users of market news information by making the news available in text form on television in their homes and/or offices.

A pilot project with a public broadcasting station using Line 21 broadcasting is currently underway in Wisconsin. By purchasing a low-cost decoder and attaching it to his TV set, a farmer can get market news information almost simultaneously with the development of the market report. Favorable preliminary results suggest that this project will be expanded—possibly nationwide.

Probably the biggest challenge for the future will be how to handle adequately the volume of products produced for the domestic and export markets in the 1980's and beyond. Given changing patterns of domestic use and increases in agricultural production moving into exports, a 3 percent annual rise in production will generate a 4 percent increase in agricultural marketings.

By the mid-Eighties, the volume of products moving through the marketing system could be as high as 775 million tons, compared with an average of 560 million tons in the Seventies. To reach the export ports they require the same basic transportation equipment and much of the same storage and marketing facilities used in the domestic marketing system.

Much of the burden to handle this expanded volume will have to fall on rail transportation. Yet the railroad transportation capacity has actually been declining due to bankruptcies, mergers, and consolidations.

The increases are also likely to tax the storage component of the marketing system. Strategically located storage capacity will be in greater demand to relieve pressure on the transportation system during critical harvest periods.

Finally, there is the question of what the effects of these pressures on the marketing system will do to domestic consumer food prices. We have done well in the past in meeting many challenges when we had a technology base to draw on. Can we do the same in the future?

Author Harold S. Ricker is with the Agricultural Marketing Service, Washington, D.C., and coauthor William H. Tallent with the Agricultural Research Service at Peoria, Ill. Both services are USDA agencies.

Further Reading:

Agricultural Energy, Vol. 3, Food Processing, (Selected papers and abstracts from the 1980 ASAE National Energy Symposium), available from American Society of Agricultural Engineers, 2950 Niles Road, P.O. Box 410, St. Joseph, MI 49085. $9.50.

Marketing Opportunities for the Retort Pouch, David A. Heintz, *Food Technology,* September 1980, pp. 32-38, 102.

Proceedings of the National Food Loss Conference, available from John O. Early, Agricultural Science Building, Room 30, University of Idaho, Moscow, ID 83843. $5.

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he World Outside

AID PHOTO

Meeting Food Needs Elsewhere in the World

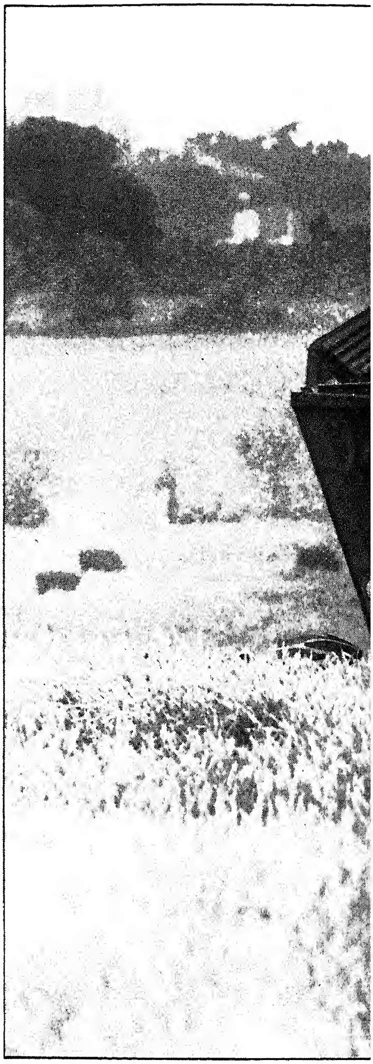
By Clare I. Harris

Despite an ever increasing world population, food production per capita has steadily increased over the past few decades in both the developed and the developing nations. However, the gains have been modest. And food supplies in many parts of the world do not provide diets adequate for good health.

The continuing population growth and the need to improve diets in a number of countries present a tremendous challenge to the world's agriculture. World population reached 4 billion in 1975, and is expected to exceed 6 billion before the year 2000.

American agriculture currently is playing a key role in providing food for the world. About 56 percent of major grain crops and 53 percent of soybeans that entered world trade in 1979/80 and 1980/81 originated in the United States. Besides our dominance in grain and oilseed crop exports, the United States also exports significant amounts of livestock, fruits, nuts, vegetables, and their products.

Even when looking at all production, the United States dominates the world picture for some major crops, producing 48 percent of the world's corn and 64 percent of the soybeans in 1979.



TIM McCABE

Altered Perspective

A look at total world food production gives a different perspective, however, with—for example—U.S. production accounting for only about 14 percent of the world's wheat and less than 2 percent of the world's in 1979. This sobers one's notions the contributions the United Stat can expect to make in helping foo

American farmers currently play a key role in providing food for the world, supplying about 56 percent of the major grain crops.

deficit countries meet their needs in the future.

The United States has tremendous capacity to supply the current world markets with a wide variety of agricultural products. But when you expand the potential to needs of the developing nations, the quantities

involved would stretch the capabilities of our country and the other food-exporting nations as well. A further consideration is the shortage of resources in developing nations to enter normal trade channels to buy food.

It seems clear that a number of economically developed nations will continue to depend heavily on world trade channels for their food and that the United States will be a major supplier. This is quite a satisfactory relationship in which we draw on one of the richest and most productive agricultural areas in the world to produce food in exchange for natural resources and manufactured goods from countries that do not have good agricultural potential. Net U.S. exports of food and agricultural products in 1980 had a value of $15.8 billion.

Increasing food needs of the developing nations may be met, in some cases, through international trade, with the United States a principal supplier. Yet for many developing nations the most promising opportunity to meet future food needs lies in increasing their food producing capability within the country.

In the past, increased production has often been achieved by expanding agricultural operations into new areas. For the future, increased productivity on existing agricultural lands will become more important. Improvements in productivity can result from two kinds of inputs—technological and capital.

Aid by U.S. Experts

An important component of the success of U.S. agriculture has been the strong programs of agricultural research by the U.S. Department of Agriculture, the State Agricultural Experiment Stations, and industry; technology transfer programs through the Cooperative Extension Services; and supporting programs in higher education at the land-grant colleges and universities.

Agricultural systems used in the United States are not appropriate for many of the developing nations. But U.S. experts in crop and animal production and protection, soils, economics, food sciences, etc., are in a position to work with people in their local situations to conduct research and develop technologies that fit needs of the individual countries. Some interactions of the United States with developing countries are direct and others through international organizations that involve joint endeavors by a number of developed and developing nations.

The potential for increased food production through developing and introducing new technologies is great. Some will be available without supplemental inputs, while others will require additional inputs such as fertilizers and pest control materials.

The following chapters include details on trade and how it takes place, the U.S. role in meeting world food needs, and efforts to develop and introduce new technologies to increase food production capabilities of the developing nations.

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Nations Trade Food for Everyone's Benefit

By E.M. Manfredi and D. O'Flynn

Nations trade food with each other so each country can be better off. Products that residents of one country need but cannot grow are available in another, and vice versa. As two countries trade with each other, the needs of both are met.

These needs are caused by inability to grow certain foods in various countries, expanding populations, growing incomes, and changing tastes.

Most nations and societies eat food based on grains. Grains are produced in every country in the world. They are processed into flour and baked into bread or pastries, boiled as spaghetti, cooked as rice noodles or eaten like corn tortillas.

However, not all countries grow enough grains or enough of the kinds of grain desired by the population each year. In some countries, grain shortages occur each year due to the climate and soil or to the advantage of producing other agricultural or non-agricultural goods. In other countries grain shortages are sporadic, induced by weather, disease or other fluctuations which reduce grain production domestically.

Trade is the mechanism for meeting many of the different kinds of world food needs.

Maximizing Returns

Countries with grain shortages fill their needs by importing from countries with grain surpluses. Thus, the different levels of production of wheat and rice and corn in countries around the world allow the grain trade to flourish.

Nations with wheat or rice surpluses are not necessarily the largest producers in the world but they grow more grain per person than the importing countries. Or they grow specific kinds of grain with desirable taste or baking qualities, like Pakistani basmati rice and U.S. hard wheat, for which other countries are willing to pay.

To maximize financial returns, commodities are generally produced for which the country or area has an advantage. This means commodities that give the grower the greatest income after accounting for costs of production.

Land has uses other than for grain production. Land for production of wheat, for example, competes with its use for other foods, and for other agricultural commodities like cotton, or for industrialization uses, and for private and public recreational uses.

The commodity which gives a country the greatest advantage tends to be what that country exports. The level of exports depends on how much is produced and how much consumed domestically.

Effects of Income

The level of foodgrains which a country imports also depends on current domestic production, as well as accumulated stocks, and the level of demand. When economists speak

of demand they mean "effective demand," that is, consumer needs backed by purchasing power.

Thus, the level of demand depends on population and income levels and changes in those levels each year. Generally it is assumed that the demand for such basic foods as grains will grow with population in a country.

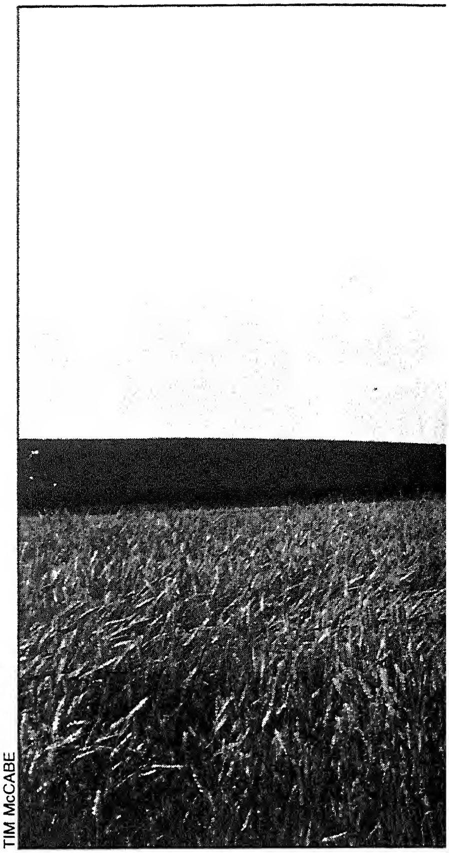
Population in recent years has been growing at around 1 percent a year in the more developed countries and up to 3 percent a year in the lowest income developing countries. World population growth in the late 1970's was about 1.8 percent a year. Meanwhile, grain production for food rose faster, at an average annual rate of 2.5 percent. This means that only part of the growth in foodgrain consumption can be explained by population increases. The rest is explained by income growth.

Income growth leads to somewhat higher grain consumption levels, especially among poor people. However, the more dramatic effect is that of shifts among types of food in the diet.

In poorer regions, a rise in income leads to switching from roots, tubers and other starchy foods to higher-priced grains.

Middle income people switch to higher-priced foods such as meat products. Increasing purchases of meat and higher prices lead to a buildup of livestock herds which need grains and other protein sources, such as soybeans, for feed.

Some countries import food to improve their diets and satisfy growing populations. Certain African countries, such as Nigeria, grow and eat large quantities of cassava and yams, which are like sweet potatoes. As their populations grow and as they have more money to spend, the traditional crops no longer are adequate. These countries then must rely on trade to supply their new needs.



TIM McCABE

Wheat, for example, is especially desired in such countries since it can be made into bread. Bread is convenient to store and carry, and is becoming the preferred food of city dwellers in many developing countries.

Grain is produced throughout the world, but many nations don't grow enough to meet domestic needs. They must rely on countries that produce in abundance.

Consumers in Middle Eastern countries want to eat more meat products than they have traditionally. So they import frozen poultry from the United States. This is an example of food needs caused by changing tastes.

Another country may find it too expensive to raise certain crops because its climate is too cold or its soil too rocky. Some countries are completely unable to raise certain products—England can't grow tea, for example, and must obtain it by trading with Asian growers.

Growth in World Trade

Because of the many different needs met by trade in food, and the growth in world population, food trade has climbed rapidly in recent decades. In 1980 three times as much grain was traded between nations as in 1960. That equals 229 million tons of grain in 1980 compared to 76 million in 1960. It only took 1,900 ship cargoes

Whether importing or exporting, all countries benefit from food trade. In 1979, agricultural products amounted to 14 percent of total world exports.

to carry that much grain in 1960; today it would take 5,725.

As the amount of food traded has grown, a larger share of it is eaten in a different country than where it was grown. In 1960, some 10 pounds in every 100 were consumed outside the country of origin. Today that ratio is 15 pounds out of 100.

Because of trade the world enjoys a higher standard of living than if each country depended on what it could grow by itself. We said before that world trade in cereals had grown from 76 million tons to 229 millio over 20 years. This growth in grai trade from 1960 to 1980—153 mill tons—is the amount world trade l added to annual world food consun tion in that period.

The amount is equal to about 7 pounds of cereals for every inhabi ant of the globe. If trade had not grown since 1960, on average eacl person in the world would have 75 pounds less at his disposal thar

he does today. This is out of total consumption of about 710 pounds.

Thus, trade magnifies the ability of world agriculture to meet food needs. Availability of cereals to world consumers has grown twice as fast as it would if each country tried to stay self-sufficient. For this reason our hopes for a better standard of living for the earth's growing billions depend heavily on trade between countries.

Africa is a good example. If we look at African countries south of the Sahara desert, we see that 2½ times more cereals were consumed there in 1980 than in 1961.

During those two decades the population soared, and increased income created a demand for non-traditional foods. But the inability of the soils, climate and farming systems of the region to grow more food-grains prevented local producers from meeting the needs. As a result, countries of the region traded for the grain supplies, and found that they needed to increase imports of cereals dramatically to keep up.

Trade's Importance

Food trade is very important to both exporting and importing countries. In 1979 the value of all food and other agricultural products shipped from the country where it was grown to the country where it was eaten equalled $228 billion. This is 14 percent of the value of total world exports of all commodities—including cars, computers, clothes and other goods.

All imaginable types of food are traded between countries, but the largest category is grains. A handful of countries dominate world exports of foodgrains because of their large production of wheat or rice relative to domestic consumption levels.

The United States, Canada and Australia lead in wheat sales to the world. The United States leads the world in wheat, corn and rice sales. Thailand and several other Asian countries also have large exports of rice.

Most countries, however, eat all they produce of basic foods like grains and buy additional supplies they need abroad. Almost all countries export some type of food but many specialize in products for which their climate, soil and terrain are especially suited.

Many countries in tropical climates produce foods like coffee, tea, sugar and bananas and sell them to other countries. Examples of countries which depend on sales of tropical products for a large part of their export earnings include: Colombia—coffee, Ghana—cocoa, Sri Lanka (formerly Ceylon)—tea, and Ecuador—bananas. None of these commodities can be grown in the United States or other temperate zone countries.

On a smaller scale, various spices have been historically important to both selling and buying countries. Salt was needed long ago to preserve food, especially meat. Today salt and a large variety of exotic spices are traded to satisfy consumer tastes all over the world.

The role of food exports is twofold: 1) to satisfy needs and tastes of people in other countries, and 2) to provide cash to exporting countries which allows them to pay for their own imports of other foods or nonfood items. Some countries depend on revenue

from agricultural exports to pay for the bulk of their imports of other goods.

The cash a developing country receives from exporting tropical products can buy machinery, chemicals, and personal consumer items manufactured in the industrialized countries. In return, importing countries can buy goods they could not have produced within their own borders. This two-way trade fills a need by allowing desires to be satisfied in many countries at the same time.

Balance of Trade

The agricultural trade balance is the difference in value between imports and exports of agricultural commodities for a country. These include all kinds of foods and other nonedible agricultural goods like cotton, tobacco and natural rubber.

Each country's agricultural trade balance is different. Those countries that export a higher value of foods, beverages, fibers and other agricultural goods than they import have a positive agricultural trade balance. A surplus in agricultural trade allows a country to import other kinds of goods or to increase holdings of international monetary reserves, much like an individual's savings account.

In contrast, a country that imports a greater value of agricultural goods than it exports has a negative agricultural trade balance. Such countries are in a deficit position and must export more of other commodities, like cameras, handcrafts, oil, or metals to pay for their deficit in food trade. If they are unable to pay for the food trade deficit with other kinds of exports, nations must resort to borrowing from the international banks, requesting food aid from donor countries (such as the United States), or using their accumulated savings of foreign currencies.

Among the major economies in the world, the United States, Canada and France are the only ones with a traditional surplus in agricultural trade.

China and a number of developing countries also have agricultural trade surpluses. Agricultural goods dominate many of those countries' exports while their imports consist largely of manufactured goods they cannot produce locally, and equipment and inputs for development projects.

U.S. Largest Exporter

The United States is the world's largest agricultural exporter. Even with substantial imports of commodities like meat, fruits, cheese, sugar, wines, coffee, cocoa, tea, spices and natural rubber, there is a high surplus in U.S. agricultural trade.

For the fiscal year 1980 (ending September 1980), U.S. exports of agricultural goods brought in $40 billion and imports cost $17 billion. That left a net surplus of $23 billion in agricultural trade to help pay for other goods, like oil and manufactures.

The overall U.S. trade deficit has worsened in recent years. However, the agricultural trade balance has improved, with the surplus growing during the 1970's. In the late 1970's the agricultural trade surplus paid

The export market is important to the American farmer, accounting for one of every five dollars in gross farm income.

DONALD BRENEMAN

for 39 percent of our oil imports.

The United States is the world's leading exporter of wheat, corn, rice, soybeans and cotton. This is because U.S. production exceeds domestic use. Efficient farmers get high yields per acre for crops which they sell to trading companies or cooperatives.

Unlike many other countries, the U.S. Government is not directly involved in selling farm products overseas. Private commodity traders, grain companies, farmer cooperatives and exporters are all involved in selling to companies and governments abroad. Prices are determined by world supply and demand factors with adjustments made for quality differences.

Our Farmers' Stake

The export market is quite important to American farmers. Produce from one of every three acres harvested in the United States is exported. In 1977, more than one of every five dollars in gross farm income (before deducting expenses) came from exports.

U.S. consumers benefit from exports because foreign demand for U.S. commodities keeps production levels high and costs down. Also, with foreign markets eager to consume U.S. grown foods there is less need for large government outlays for agricultural price or income support programs than in the past. Thus, use of taxpayer money for farm programs is minimized.

The large U.S. agricultural trade surplus helps keep the dollar strong by lessening the U.S. trade deficit on non-agricultural items. In recent years agricultural exports have equalled more than 20 percent of total U.S. exports.

U.S. exports of agricultural com modities have helped feed the wo and that role has been growing o the past decade. The basket of go that we sell the world has change sharply, however.

In earlier years, food demand i the rest of the world was met by s of U.S. wheat and rice for direct human consumption abroad. The other grains we export—such as corn, barley, oats and sorghum—a used basically as animal feed. Th enter the human food supply whe livestock products are consumed.

Feedgrain Sales Soar

The big change in composition of U.S. agricultural exports has bee the sharp increase in sales of fee grains (such as corn) and other animal feeds like soybeans.

As income has risen in the developed countries, part of the ext income has been spent on impro diets. Meat consumption in devel countries has been rising and wi the need for animal feeds. U.S. e ports of corn and soybeans to be to chickens, hogs, and cattle over exceed the value of exports of wh and rice to be eaten directly by consumers.

The poorest countries continue have the bulk of the world's pop tion. Besides, there is a growing gap between minimum nutrient calorie requirements for each in vidual and the food availability these countries.

The poorest countries cannot a to sharply increase their foodgra purchases from the world marke must rely to some degree on food The United States provides abo million tons of food aid to the po

countries. The rest of our agriculture exports are sold for cash.

Income growth per person in the developed counties and in the richer developing countries has been higher than for the countries of South Asia and Africa where the large food gaps remain. The demand for meat products in Europe, Japan, South Korea, Taiwan and other high and middle income countries has grown in the last decade.

Demand in foreign markets for U.S. agricultural products has been rising because of the two factors already mentioned—population growth and income growth.

Population growth is higher in the poorest developing countries. They will continue to import basic grains for human consumption—wheat and rice—to supplement their own domestic production.

As income grows, however, people spend more on other kinds of foods. The higher income developed countries will continue to spend more money on imports of feedgrains and other animal feeds to meet growing consumer demand for pork, poultry and red meats.

Future Role of Trade

The future role of agricultural trade depends on many factors—population growth rates, income growth, changes in dietary preferences, and policies in producing and trading countries. The volume of world trade in agricultural commodities should continue to grow. Nevertheless, the world food problem of malnutrition in many countries cannot be solved totally by expanding trade.

Developing countries which are facing a growing food gap must increase food production in their own countries. This can be done by establishing favorable internal policies to promote food output.

Higher production levels can be achieved by expanding planted acreage and by increasing the yield per acre. This will come about largely through improved cultivation methods, more extensive irrigation and increased use of fertilizers.

The world population growth rate may decline in the 1980's but by 1985 the total world population may rise by 75 million people each year. Bulk of the population increase will be in the developing countries where diets center around basic grains. But the ability of these countries to pay for food imports is limited. This is why increased production within the developing countries will be needed to meet food needs.

Rising supplies of foods and other agricultural commodities are expected in food-exporting countries during the 1980's. Yet, the export potential of the world and of individua countries is not unlimited.

Production constraints may show up due to problems with soil erosion on land under intensive cultivation. In addition, the ability to ship and handle increasing quantities of bulk food items depends on available ships, docks and storage facilities.

Food trade will expand in coming years and it will continue to benefit the United States and the rest of th world. But trade alone cannot solve the world's food problems.

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public companies are direct exporters of U.S. agricultural commodities. Most direct exporters handle relatively few, related commodities and a large number serve the United States as well as foreign markets.

Firms that directly export U.S. commodities include both American and foreign companies. Export merchants and export management companies are two major types of direct exporters. These companies are based in the United States and they purchase goods for export from U.S. suppliers or act as their export representative. Foreign buying offices and export commission houses are also forms of direct exporters who purchase and export commodities from the United States on behalf of foreign customers.

Sometimes it's hard to determine the nationality of direct exporters. A number of exporters of U.S. agricultural products have offices in many countries where they buy, sell, export, and import goods. They often are referred to as international trading companies.

Access to Products

Direct exporters must have access to products demanded by foreign buyers to sell goods in the international marketplace. An exporter's primary concern, therefore, is to acquire a sizable and relatively stable supply of commodities.

This may be done by personally producing goods for sale abroad. For example, food manufacturers sometimes export products they process at their plants. Alternatively, direct exporters buy goods from farmers, elevators, processors, brokers or any other producer or handler of agricultural commodities that can meet their commodity needs.

The word "product" in an export transaction refers to a commodity plus a mix of marketing services. An exporter must acquire the types, qualities, and quantities of commodities requested by foreign buyers. In addition, he or she must be ready to carry out market development activities, quote a price for the shipment, physically prepare the order for movement abroad, and deliver the products to the overseas customers.

Foreign buyers have different marketing service requirements. For example, market development activities are not as important to a large number of grain buyers as the ability to deliver at a low price.

Key to a successful export business is ability to identify and satisfy "product" needs of potential customers. To the extent the exporter is able to differentiate his commodities from those of other sellers through performing unique and essential marketing services, the exporter will stabilize his markets and increase his profit opportunities.

Foreign Buyers

Design of an appropriate commodity and marketing service mix requires

an understanding of the potential uyers. Like that of U.S. exporters, the nature of the customers who purchase U.S. goods is very diverse.

Exporters of various commodities often serve different types of buyers. Produce exporters sell to food wholesalers and retailers, hotels and restaurants, import agencies, and trading companies. In contrast, major buyers of U.S. grains are feed compounders, oilseed processors and crushers, flour millers, trading firms, and government agencies.

An exporter's markets as well as his commodities affect the types of customers he deals with. Each country has a different political, cultural, and food distribution system which influences the number and nature of its buyers for a particular commodity.

The majority of citrus fruit sold to Japan, for example, is bought by large trading companies. They control 80 to 90 percent of Japan's foreign trade and are well integrated into the domestic marketing system.

Trading companies are licensed by the Japanese Government and many have established subsidiaries in the United States. Title to the fruit, therefore, is often assumed by the Japanese company before shipment overseas.

By comparison, shipments of fruit to the U.S.S.R. are purchased by a Soviet Government foreign trade organization. Government buyers purchase fruit by direct contact with U.S. exporters or indirectly through firms in Western Europe. Title to orders is transferred to Soviet buyers in the United States, Western Europe, or the U.S.S.R.

Once the exporter is satisfied with his sources of commodities, he can sit back and wait to receive orders. port sales are sometimes made little market development effor exporters who follow this practi usually small in size. Buyers w seek a unique commodity or ha heard of the exporter through o suppliers may take the initiati establishing contact.

Identifying Markets

A more rigorous marketing eff required of exporters who desir large and consistent volume of An important component is ide ing markets that offer the best opportunities.

Markets are evaluated by ga ing data on consumer tastes an incomes; adequacy of domestic supplies; tariffs, quotas or othe trade barriers; and extent of co tion in the market. Much of thi is often available from U.S. so Exporters, however, often visit kets to get additional informat well as to contact potential bu and distributors.

Market evaluations often ide constraints to sales of the expo products. Many constraints, su little consumer exposure to the porter's goods, can often be re by market development activit

Foreign market developmen includes well-known promotio techniques such as advertising consumer and trade magazine distributing recipes, point-of-s promotions in retail stores, an participating in trade fairs.

Less familiar tools also help export constraints and increas Among them are seminars on cient marketing and handling of potential buyers to the Uni

States, and technical assistance to modernize production and processing facilities that require agricultural products as inputs.

Most exporters have some type of sales organization to help with their marketing efforts abroad. These organizations initially consist of export brokers and U.S.-based salesmen who primarily establish and maintain contact with potential buyers.

As the exporter's business grows, his sales network often increases in complexity and plays a greater role in transactions. Export commission representatives, foreign distributors, and foreign offices of the exporter's company gather market information, carry out market development, relay price quotations to buyers, and handle problems during shipment.

Price Quotations

An export transaction may be initiated by either the exporter or the foreign buyer. The exporter may telex his commission representative or customer with a price offer. The buyer, on the other hand, may contact the exporter and ask for a price quotation.

A price quotation is an offer of the exporter's products that contains more than just the shipment's price. The quotation specifies type, quality, and quantity of commodities offered the customer; price requested; terms of trade and point of delivery; delivery date or shipping period; instrument by and currency in which payment is to be collected from the buyer; and quotation validity period.

One of the most important components of a price quotation are trade terms of the offer. They determine extent of the exporter's responsibilities in a transaction. For example, free alongside (F.A.S.) steamer terms require the exporter to deliver the goods to an ocean vessel at a U.S. port. He must also pay all expenses and acquire all the documentation needed to move the order to that point.

In contrast, the exporter retains responsibility for the shipment until it arrives at the foreign port in a cost and freight (C.&F.) foreign port transaction. Other terms frequently included in export price quotations are free-on-board (F.O.B.) steamer; and cost, insurance, and freight (C.I.F.) foreign port.

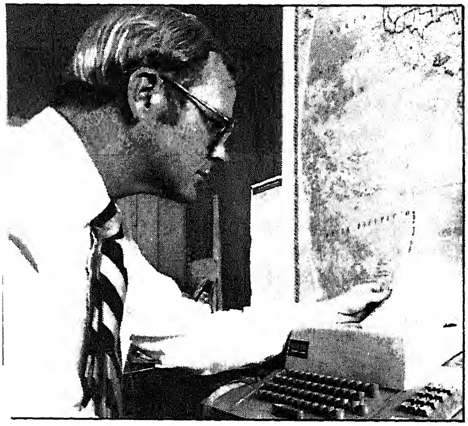
Trade terms as well as other components of a price quotation affect costs the exporter considers to quote a price for the shipment. These expenses may include cost of acquiring goods from suppliers, sales agents' fees, market development expenditures, order preparation and inspection charges, inland and ocean transportation expenses, freight forwarder and port fees, and financing charges.

Other Factors

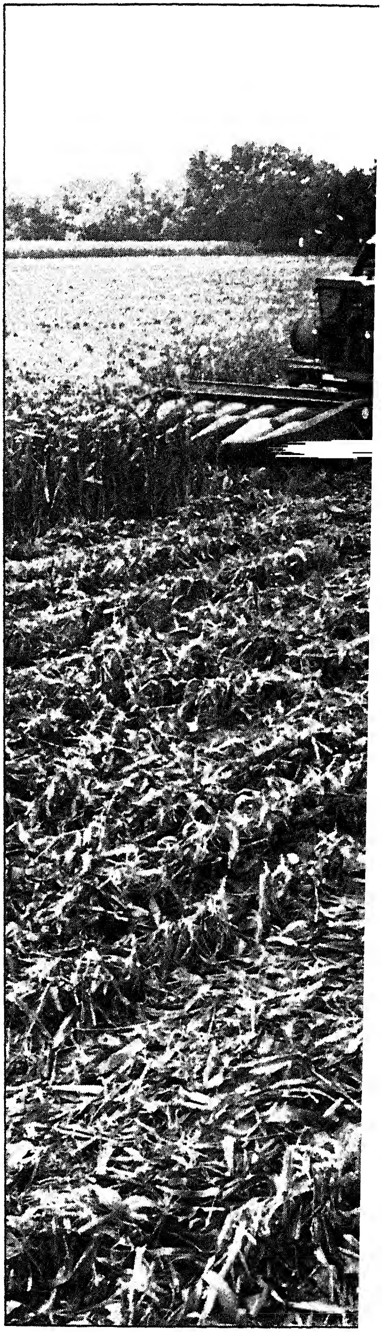
The exporter, however, does not just examine his costs to quote a price for his products. He continually gathers and analyzes information on such factors as possible fluctations in transaction expenses, commodity supply and demand situation in the buyer's country, risk involved in collecting payment from the customer, his own inventory levels and freight positions, and competitor activities and possible prices.

He then tries to select a price that covers expected costs and capitalizes on profit opportunities without los-

Agricultural exporting firms aren't all giant conglomerates. Many are small companies that specialize in a limited number of products. One such company is Coastal International, founded three years ago and operated by the father-son team of Charles and William Howard. Its headquarters is in the small town of Easton, Md., amid a rich vegetable growing region some 60 miles from the port of Baltimore. The Howards specialize in canned and frozen vegetables and serve the Caribbean area primarily, with some business in the Middle East.



William Howard checks the telex machine for food orders at his exporting firm at Easton, Md.



Much of the food exported by Coastal International is grown and processed on Maryland's eastern shore, where the firm's headquarters is.

ing the sale to competitors. This price and the remainder of the quotation are transmitted to the foreign customer.

If the customer is dissatisfied with the quotation, he may refuse the offer or fail to respond within the time period allotted. Alternatively, the customer may attempt to negotiate a lower price or a change in other parts of the quotation. As soon as he is satisfied with the offer, the quotation is accepted and the terms become the basis for an export order.

Telex confirmation of the final offer is sometimes regarded as a binding sales agreement in international transactions. In situations involving large export revenues, however, a formal sales contract is signed by exporter and buyer.

This contract may be a sales document which is drawn up for that particular order. On the other hand, a standard sales contract which contains clauses common to a large number of transactions is frequently completed. Examples of standard agreements are the North American Export Grain Association (NAEGA) contracts and the American Cotton Shippers Association F.O.B./F.A.S. Contract.

Hedging Sales

The exporter may acquire commodities from suppliers before receiving an export order. Or he may sell goods to foreign customers and then buy products for shipment abroad.

Either situation involves price risk for the exporter. Since commodity prices fluctuate frequently, he may not be able to recover from buyers the full cash price he paid suppliers for their goods.

Exporters of some commodities reduce price risk by using commodity futures markets. They sell futures contracts as "excess" inventories are accumulated and buy futures upon receiving export orders. The reverse is carried out where offers have beer accepted and commodities have yet to be obtained.

Exporter hedging activities can often succeed in reducing risk since futures and suppliers' prices frequer move together. Thus, profits in the futures market offset losses in cash transactions.

An export order may be filled within a few days. Several weeks tc a year, though, is the normal time between accepting a quotation and delivering the products. To fulfill th terms of an export sales agreement the exporter must perform a numbe of order preparation, transportatior and exit port activities.

Agricultural goods are produced in all regions of the United States. After harvesting or storing their commodities, growers and farmers truck them to processing or handli facilities near the growing area. Many of the facilities are owned b exporters or their suppliers, and often serve as the order preparatio points for export shipments.

The exporter instructs his employees or suppliers to assembl the goods specified as the order de livery date nears. He also asks them to perform marketing servic needed to transform the commodit into products sought by the buyer

The services frequently are like those carried out for domestic shi ments and vary by type of commo ity. Cattle hides are fleshed, salte inspected, and weighed at slaugh

ing or meatpacking plants. Produce packers wash, sort, grade, and sometimes fumigate fresh fruits and vegetables.

Packing, Inspection

Except for most grain shipments, agricultural orders must be packed for movement to overseas customers. Containers are selected that protect the goods, minimize customs duties and freight charges, and conform to packing laws of the importing country.

Packing methods differ by commodity. Cotton is wrapped in jute bags, fruit juice concentrate poured into steel drums, and oranges packed in fiberboard cartons. The "packages" then are often put in intermodal containers. These large aluminum containers are sealed at U.S. order preparation points and opened only upon arrival at their foreign destinations.

Many containerized and other shipments are not moved from inland facilities until they are examined by Federal or State inspectors. Two types of inspections are frequently required for export orders. Phytosanitary inspections help insure the products are free of disease or insect infestation. Then there are U.S. grade and weight inspections at the handling facilities.

The goods are now ready to be moved to a U.S. port by rail, freighter, truck, or barge. Exporters of sizable quantities of commodities often are able to cut freight costs by purchasing or leasing a significant part of their inland transportation fleets.

Port Activities

Many exporting firms have offices in port cities. One of their key functions is to see that orders are delivered by inland carriers to the shipping pier or handling facilities at that point.

At the pier, initial or additional order preparation activities may be carried out. For example, large quantities of grain are moved to port elevators by barge or unit train. The grain, however, may not be separated into cargoes, blended, and inspected for specific buyers until it moves through port facilities. In contrast, port cargo sheds often serve as order consolidation and containerization points for fresh produce shipments.

Exporters' port order preparation and other responsibilities demand the services of many people. Yet it is uneconomical for exporters to set up offices at every export point. As an alternative freight forwarders are employed. These independent middlemen specialize in handling export product movement and documentation tasks. They play an important role in most export transactions.

Freight forwarders begin assembling export shipping papers as soon as port order preparation activities are completed. These papers include a shipper's export declaration for U.S. customs officials. Also included are documents to satisfy the foreign customer and officials of the importing country.

Documents may include an export commercial or consular invoice, certificate of origin, marine insurance certificate, bill of exchange, ingredient and inspection certificates, fumigation and phytosanitary certificate, and dock receipt or ocean bill of lading. In many cases, documents required by the buyer must be certified by the consulate of the import-

Getting Paid

The exporter's full attention, however, is not focused on other orders until payment has been collected for the shipment. He may receive immediate compensation for the items, frequently before they leave the United States, by demanding payment by such collection procedures as cash against documents or a letter of credit.

Alternatively, the exporter may wait 14 to 120 days for reimbursement. In a sight draft, documents against acceptance transaction, he is paid soon after the goods arrive at the foreign port. Sight draft, documents against payment financing terms often increase the collection period 30 to 90 days.

The exporter's choice of a collection procedure is an important part of his "product mix." Financial instruments requiring immediate payment for orders involve the least risk for the exporter. However, they may reduce the exporter's sales if his competitors offer more favorable financial terms and comparable prices to buyers.

On the other hand, sight draft transactions frequently increase the exporter's competitiveness and the possibility the customer won't pay for the goods. So the exporter must carefully evaluate the amount of money involved, the buyer's credit record, and financial terms offered by competitors. He must also examine the market, financial, and political conditions of the importing country, before selecting a financial instrument for a particular order.

Bernie hung up the telephone. He rubbed his ear, red from many hours of conversation and the blistering comments of his awakened friends. Yet Bernie felt he now was in a better position to realistically evaluate the possibility of exporting his products. He stood, switched off his desk lamp, and headed home for a good day of sleep.

Daleen D. Richmond is an Agricultural Economist, Office of Administrator, Foreign Agricultural Service.

Further Reading

Agricultural Export Market Development and Promotion, David A. McKinna, #AE Extension 78-30, available from R.B. How, 442 Warren Hall, Cornell University, Ithaca, NY 14853. Free.

Exporters' Encyclopedia, Dun & Bradstreet, for sale from Exporters' Encyclopedia, P.O. Box 2007, Jersey City, NJ 07303. $265.

Export Marketing Guide for Cooperatives, available from Marge Christie, Agricultural Cooperative Service, USDA, Room 0054-S, Washington, DC 20250. Free.

How U.S. Cotton Is Sold for Export, Foreign Agricultural Service, USDA, Room 5918-S, Washington, DC 20250. Free.

Improving the Exports Capability of Grain Cooperatives,, available from Marge Christie, Agricultural Cooperative Service, USDA, Room 0054-S, Washington, DC 20250. Free.

U.S., Farm Groups Build Markets—and Income

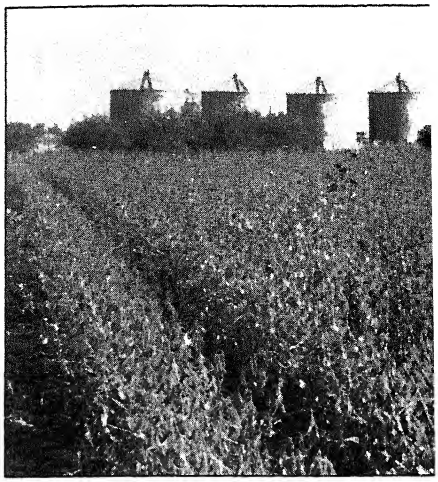
By Jimmy D. Minyard

In the early 1950's, a course was charted for U.S. farmers that has had a major impact on today's farm programs. A concept of export market development was embodied in the Agricultural Trade Development and Assistance Act of 1954, more commonly called Public Law 480 (P.L. 480). This Act recognized the potential for sales of farm products in foreign markets and established mechanisms to capitalize on those markets for U.S. farmers.

Two of the more significant features of P.L. 480 were: 1) the idea of using surplus farm products to build an export demand; and 2) providing a mechanism for producers to help develop markets overseas. Both proved extremely workable.

A unique Government/industry program to promote export sales evolved from the two concepts—a program that has successfully expanded foreign sales of farm products from less than $3 billion in 1955 to more than $40 billion in 1980.

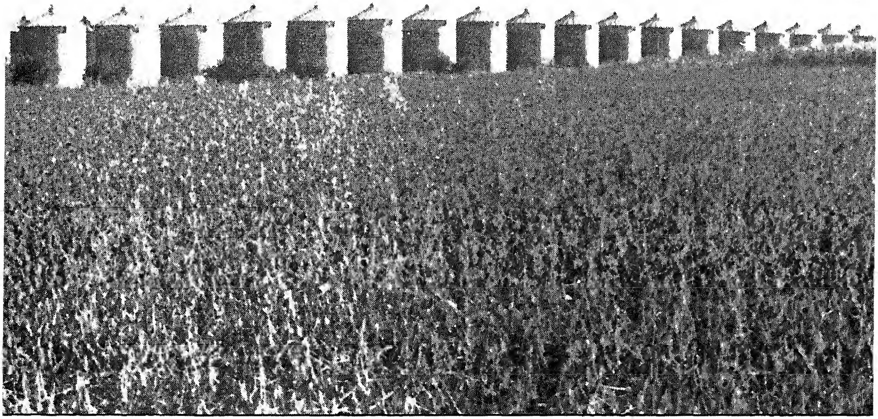
The idea of a world market for U.S. farmers, although spelled out in P.L. 480, was slow in developing among farm producers and in domestic farm legislation. While P.L. 480 became law in 1954, a market-oriented farm program did not really start to evolve until 1968. This program recognized the desirability of producing for domestic and export sales instead of a rigid program of production control and government purchases for storage of all surplus commodities.



Producer interest in export programs and support for them really took off following the massive purchase of grains by the Soviet Union in 1972 and the subsequent sharp rise in grain prices. Farmers finally recognized that exports were the controlling factor in farm prices, and offered the potential for prices far above prior support levels guaranteed by the Government.

A look at the steady growth in farm exports and the contribution of overseas sales to farm income shows the remarkable story of competitive industry activity working to expand markets.

Projections for farm exports of $65 to $70 billion and up to $100 billion by 1990 seem attainable. It is important not only to producers, but to the



Government storage of surplus grain ended when the U.S. capitalized on the world market for American farm products.

consumer and the general economy of the United States, that farm exports continue to grow since exports 1) assure full production with subsequent lower unit costs; 2) help strengthen the U.S. economy through activity generated to support export trade and a strong dollar in international trade; and 3) offer the opportunity to maintain the farm industry at profitable levels.

While exports are important to all farmers, the share of total production and exports varies significantly by product.

Market Development

P.L. 480 provided for use of a share of the funds generated by concessional sales to develop markets for U.S. agricultural products. It was decided that nonprofit commodity trade groups broadly representative of the total output of a commodity should be in the forefront of the effort to expand export sales.

Obviously, agricultural producers stand to benefit most directly from export sales. But unlike other industries, the producers themselves do not normally export directly. By involving producer associations, it was felt that more complete industry involvement was possible. This, too, proved a very workable concept.

The Foreign Agricultural Service (FAS) has more than 50 so-called cooperator agreements with various commodity groups to promote farm exports. There are also agreements with four regional groups of States and a sizable number of export in-

centive agreements with private firms.

Cooperator agreements are the backbone of the FAS export promotion program. More than 80 percent of the total annual promotional effort is through these cooperator groups—ranging from almonds to wheat.

Although every cooperator approaches each overseas market with an individual program, there are two basic approaches to market development. They are 1) trade servicing, used mainly by cooperators promoting bulk commodities; and 2) promotion to consumers, a mainstay of cooperators promoting consumer-ready items.

Trade servicing is directed at trade and industry groups handling imported U.S. farm products. Program activities are developed to provide information to importers, to assist processors with technical problems, and to help end-users properly utilize the U.S. product.

Hundreds of Approaches

Literally hundreds of approaches are possible to service the trade groups that buy U.S. farm products. But the end result is to provide customer service for the U.S. agricultural producer with his customers overseas, a role not generally performed by the export companies.

Some of the most frequently used activities in trade servicing are trade teams of foreign buyers and users visiting the United States, monthly or quarterly newsletters to overseas contacts, demonstrations of the benefits in using U.S. farm goods, travel of U.S. technicians to visit overseas customers, and holding seminars on U.S. farm products directed to importers, processors and other trade and government interests.

Farm Exports
Calendar Years 1965-80

Year	Value	Volume	Exports as Share of Farm Cash Receipts[1]
	(Bil. Dols.)	(MMT)	(Percent)
1965-69 (average)	6.4	57	(12)
1970-74 (average)	12.8	81	(15)
1975	21.9	98	(18)
1976	23.0	114	(19)
1977	23.6	111	(20)
1978	29.4	137	(21)
1979	34.7	147	(21)
1980	41.3	163	(24)

[1] Export value adjusted to estimated farm value.
Sources: *U.S. Foreign Agricultural Trade Statistical Report* and *Agricultural Statistics.*
MMT = million metric tons.

Most of these trade servicing activities are designed to achieve long-lasting changes in overseas usage of agricultural raw materials, and results are also longer term. A cooperator's efforts to help a country establish a livestock industry can take a decade or more, but once an industry is established, the potential for continuing sales in U.S. feedstuffs is good.

Consumer promotion programs, generally more expensive relative to the value of exports, are designed either to help an importer move his products or to encourage the retail trade to handle U.S. goods.

An important share of the consumer sales effort is in-store promo-

Exports as a Share of Production for Selected Products

	Marketing Year 1980-81		
	Production	Exports	Exports/Production
	(1,000 metric tons)	(1,000 metric tons)	(Percent)
Soybeans	49,451	20,684	(42)
Wheat	64,500	41,500	(64)
Corn	168,866	64,772	(38)
Sorghum	14,936	6,350	(43)
Rice	4,800	3,200	(67)
Tallow and Grease	3,175	1,450	(46)
Almonds	135	98	(73)
Hides and Skins	945	675	(71)
Peanuts (unshelled)	1,047	204	(19)

tion. This involves demonstrations, recipe booklets, promotional leaflets, and other special in-store promotional techniques. The in-store approach has the advantage of tying the promotion to products on the shelves of the retail outlet.

Public Relations

The second major approach to consumer promotion is to have a broad public relations program prominently featuring U.S. farm products. Material is provided to general and speciality magazines, home economics instructors, institutional food outlets and newspaper food editors.

While this approach has the advantage of relatively small costs per consumer exposure, the consumer may have difficulty locating specific U.S. products on grocery store shelves overseas.

The export incentive program directly supports companies selling branded products into the export market by helping pay part of the cost of promotions with government funds.

This program initially was designed to support farmer cooperatives directly exporting fruits and nuts. In fruits and nuts, cooperatives tend to have a major share of the export business, so brands can play a significant role in tying foreign consumers to U.S. farmers.

Government funds are used only for additional promotion and are paid only on the basis of export volume. After the program was developed, it was extended to a number of other product lines. A program is not offered except on an industry-wide basis. All exporters have equal access to funds when the program is offered to an industry group.

Exhibits, Trade Fairs

From the start of USDA's overseas export expansion effort under P.L. 480, overseas exhibits have played a key role.

Initially, the Foreign Agricultural Service participated in general food and national exhibits with the various cooperators and other trade associations to build an image for U.S. agriculture and the U.S. food industry. These shows were open to the general public, and millions of people in foreign countries were exposed to the types and varieties of agricultural products and processed foods available from the United States.

The second stage of the overseas

U.S. grain sorghum exports to Japan increased substantially following a program of credit and technical service.

BOB KRAL

exhibit program was directed toward large international food shows, with participation by U.S. food processors. These shows provided opportunities for U.S. firms to meet large numbers of potential buyers at a rather nominal cost of participating in the exhibit—a much more effective initial aproach than trying to call on the same number of people at their places of business.

The third and current stage of the overseas exhibit program concentrates on small, solo U.S. trade exhibits. The exhibits generally are held in hotel ballrooms or exhibit areas, are limited to U.S. companies, and can be attended only through invitation.

Such exhibits may contain broad product lines from many companies, or be limited in scope to a few product lines—a poultry and meat show, for example. The smaller solo shows are much less costly to mount and can be targeted to a selected group of potential buyers.

Along with solo trade exhibits, USDA still participates on a limited scale in such international food shows as the world-famous ANUGA in Germany and SIAL in Paris—held in alternate years.

Activity by States

Departments of agriculture in most of the 50 States are extremely active in export promotion. Besides working with the Foreign Agricultural Service through the four regional trade groups, States mount trade missions, host visiting tradesmen, participate in overseas food exhibits and livestock shows, and provide overseas buyers with information on products available in the State.

product lines get together to visit overseas markets.

FAS arranges for a mini-exhibit and taste testing of products on the day the team arrives, then schedules a series of office calls with the local trade for the next couple of days. Afterwards the team moves on to another market to repeat the process. For a number of small markets, this approach has been very successful.

A key to success of any export promotion program is the input by representatives of the Secretary of Agriculture stationed in some 70 locations around the world. Agricultural Counselors and Attaches are stationed in U.S. Embassies while Agricultural Trade Officers generally are located in commercial office space outside the Embassy.

These USDA overseas representatives are responsible for developing market information used in planning export promotion activities, and for working with cooperators, private traders and others to help develop the market for U.S. farmers.

They approve all activities involved in the market development effort and provide on-the-spot supervision of the activities. The officials are required to help cooperators and FAS officials in Washington in planning promotion programs, and must approve expenditures of all Government funds in their country of assignment.

Agricultural Counselors, Attaches and Trade Officers are backstopped by FAS in Washington with commodity analysts, marketing specialists, trade policy specialists and, where required, by help from other USDA agencies such as the Animal and Plant Health Inspection Service, the Food Safety and Inspection Service, and the Agricultural Research Service.

There are innumerable examples of the contributions that the various promotional efforts have made to expanded sales of U.S. farm products.

In Spain, lambs formerly slaughtered at weaning are now being fed U.S. feedgrains and soybeans in heavy lamb feedlot operations—thanks almost entirely to the U.S. Feed Grains Council's efforts to introduce this feeding concept.

Wheat has become a significant part of the diets in several traditionally rice-consuming Asian countries through the work of U.S. Wheat Associates. The British are enjoying U.S. wines and U.S. beef as a result of efforts by the Wine Institute and the U.S. Meat Export Federation.

The list is endless, and in each instance the result flows from joint efforts of U.S. industry representatives cooperating with FAS staff in Washington and overseas.

Opportunities exist for continued expansion of farm exports from the United States, given a reasonable economic climate in the world. A continuation of the joint industry/Government effort to promote export sales can play an important part in assuring American agriculture of a $100 billion export market.

Jimmy D. Minyard is Assistant Administrator, Foreign Market Development, Foreign Agricultural Service.

Food Aid: Where Your Dollars Help Abroad

By C. Goodloe and F. Blott

Food imports by developing countries have climbed significantly during the past decade. For some countries this growth is the result of higher incomes and improved standards of living. But for many others, where food production has not kept pace with population growth, increased food imports have been necessary simply to keep people at existing levels of consumption.

For those countries not able to pay for increased commercial food imports, food aid has been made available to meet their growing needs. About 20 percent of the food imported by the poorest developing countries is provided on noncommercial terms in the form of food aid.

The need for developing countries to receive assistance in meeting their domestic food requirements was recognized perhaps most dramatically during the World Food Conference in November 1974.

Delegates from 130 member countries of the United Nations gathered in Rome to adopt a global strategy to overcome world hunger and malnutrition. As part of that strategy, the delegates adopted a resolution which established a goal of 10 million metric tons of grain to be made available annually to developing countries in the form of food aid.

Ten million metric tons continues to serve as a goal for the international community and in 1980 was adopted as a target for annual food assistance pledges to the Food A
Convention (FAC).

The FAC, an international agı
ment first implemented in 1968,
designed to encourage sharing f
aid responsibilities among as m
donor governments as possible.]
presently has 21 contributors pl
ing 7.6 million metric tons of an
assistance. These pledges, which
fulfilled through either grain or
donations to finance grain impo
serve as minimum targets and a
frequently exceeded, although t
million metric ton target itself l
not been met.

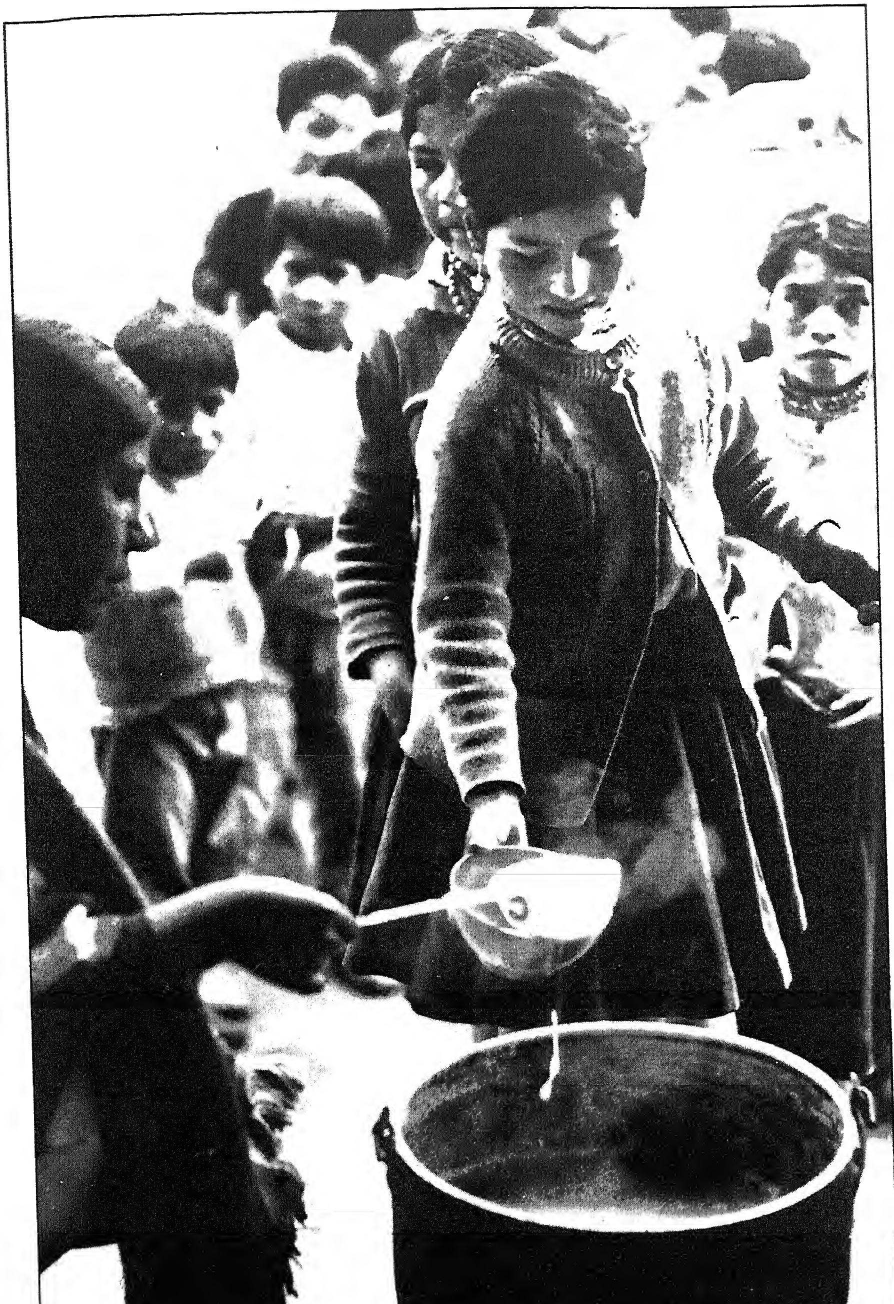
Types of Food Aid

Food aid has several forms, but
generally is provided as a donat
requiring no repayment, or is so
through a loan with very gener
repayment terms. It may be on
bilateral basis with one governr
offering assistance to another o
through international agencies.

The most obvious and probabl
best known use of food aid is to
provide relief to victims of natu
disasters and other emergency
situations—floods, earthquakes
drought, or political conflicts—t
alleviate hunger and malnutriti

In non-emergency situations f
assistance is distributed throug
feeding programs targeted towa

Twenty-one countries now contribute food aid to improve child nutrition and fill other needs.


JAMIE MARTIN, WORLD BANK

In many countries food-for-work projects provide employment and income.

people with special nutritional needs—small children and pregnant or nursing mothers. It also is used in school feeding programs that encourage attendance and promote learning ability, similar to the U.S. school lunch program. These direct feeding programs are often combined with educational programs to increase the impact of food aid in improving health and nutritional conditions.

Besides programs where direct feeding is the primary objective, food aid is used to transfer resources to further a country's economic and agricultural development. For example, after a country receives food aid, it can be resold in the local market rather than distributed directly.

The government can then inve money from the local sales in proj designed to improve agricultural production, health and sanitation services, or educational programs This investment in physical and human capital contributes to long term economic development.

Food-for-Work

Food assistance is also used to su port food-for-work projects. Here, food is exchanged for labor on pu works projects, such as constructi roads, building schools or clinics,

RAY WITLIN, WORLD BANK

digging irrigation ditches.

Food-for-work projects provide employment and income (the participants' real incomes increase because they spend less for food), while contributing to a country's basic infrastructure.

Food aid can also be used to support a country's balance of payments. Many developing countries don't earn enough foreign currency (U.S. dollars, English pounds, etc.) from their exports to buy imports such as food, machinery, and oil. Food assistance, because it is provided as a grant or purchased through a loan offering favorable repayment terms, allows a country to save scarce foreign exchange to be used for imports other than food.

Applying this foreign exchange to import fertilizer or farm machinery can contribute to better agricultural production.

Uses of food aid have recently become intertwined with questions of how to achieve food security; that is, what measures a country can take to stabilize its domestic food supplies and prices. Many developing countries face periodic production shortfalls due to poor weather or political unrest, as well as limited foreign exchange. Food aid can be used to build and maintain stocks of grain to be released in times of domestic production shortfall or high world cereal prices.

Potential Drawbacks

While offering substantial benefits, food aid can have negative results if provided under the wrong conditions or terms. To reduce the chance of this occurring, food aid has been substantially modified since its start to ensure greater sensitivity to national conditions.

The most widely recognized drawback is that food aid may serve as a disincentive to food crop production.

This may occur in one of two ways. First, food assistance sold commercially on the local market may depress prices received by local farmers and discourage them from increasing their own production. Whether this will actually occur depends upon several related factors.

If the aid is only a small part of the total domestic food supply, the chance of it significantly dampening prices is considerably reduced. Also if the food program is designed to generate

additional employment, it can simultaneously increase income and the demand for food which will in turn offset any price depressing impact.

A second disincentive occurs if governments rely on food aid to the extent that they neglect to devote sufficient resources, and avoid making policy or institutional changes, needed for developing their own farm production.

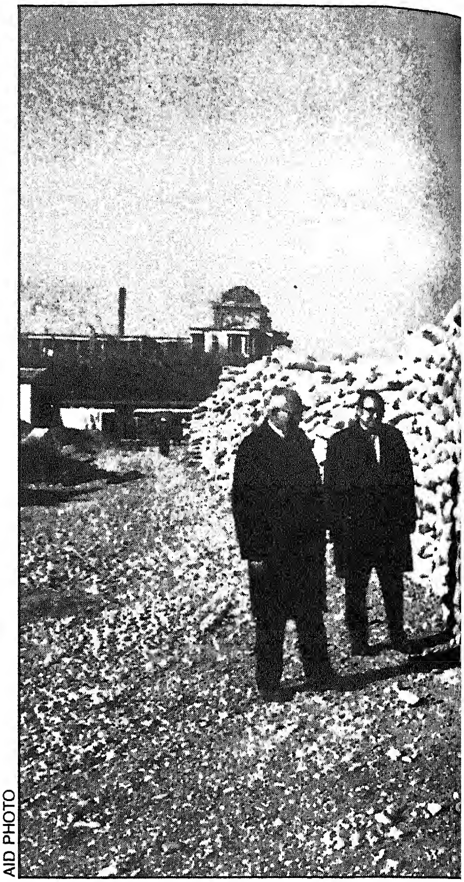
To counter this, food aid programs have increasingly been linked to supporting agricultural development through such requirements as "self help measures," provisions requiring countries to undertake specified development projects or policy changes.

Besides the disincentive effect, it has also been argued that food aid can create long-term dependency on food imports, either commercial or concessional, when a goal of greater food self-reliance would be more appropriate. Likewise it has been argued that governments can become dependent on the budget support gained from selling food assistance on the local market.

A number of factors determines whether or not such dependencies arise, but particularly the policies and objectives of the recipient countries. Since the number of former food aid recipients continues to grow, long term dependency would not appear to be a widespread result of food aid.

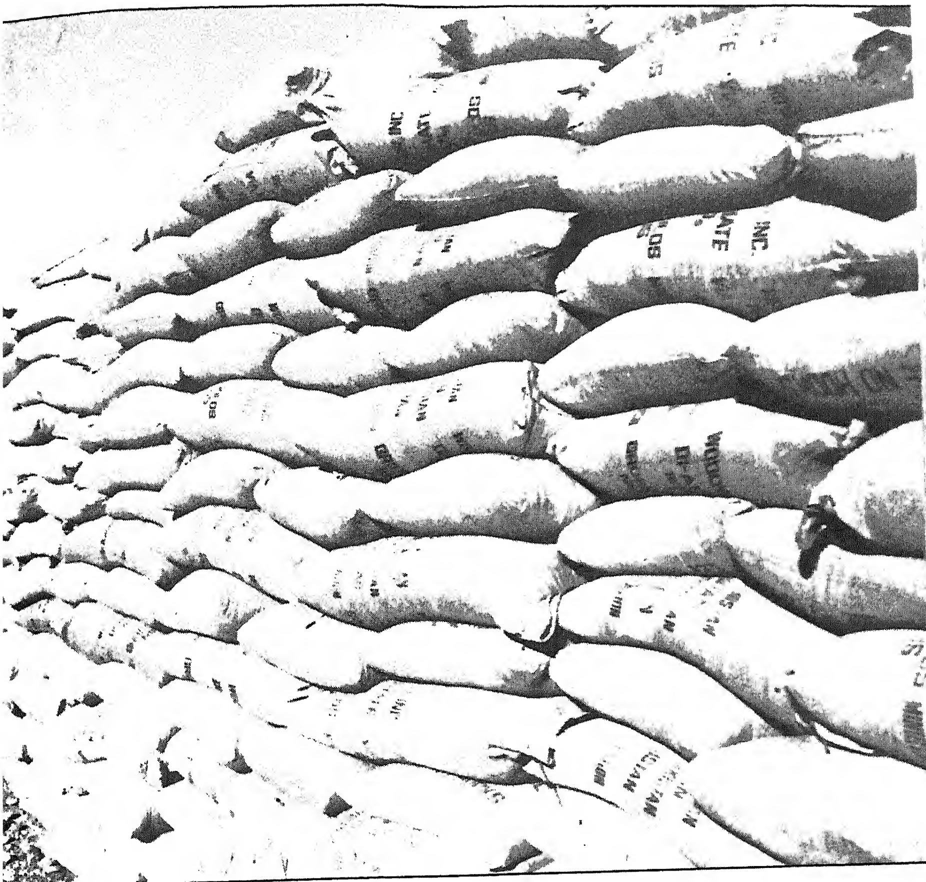
U.S. Food Aid

The United States traditionally has been the largest contributor of food aid in recent years. Besides, food aid has been a substantial portion of total U.S. help to developing countries—as much as 30 percent of all U.S. assistance.


AID PHOTO

Public Law 480 (P.L. 480) or the Food for Peace program is the primary means by which the U.S. Government provides food aid to other countries. Enacted in 1954, P.L. 480 has four legislative objectives: provide humanitarian assistance; expand international trade and develop markets for U.S. agricultural commodities; support economic development within developing countries; and promote the foreign policy of the United States.

Food commodities supplied under



Food aid allows developing countries to use foreign exchange to import fertilizer or farm machinery to improve agricultural production.

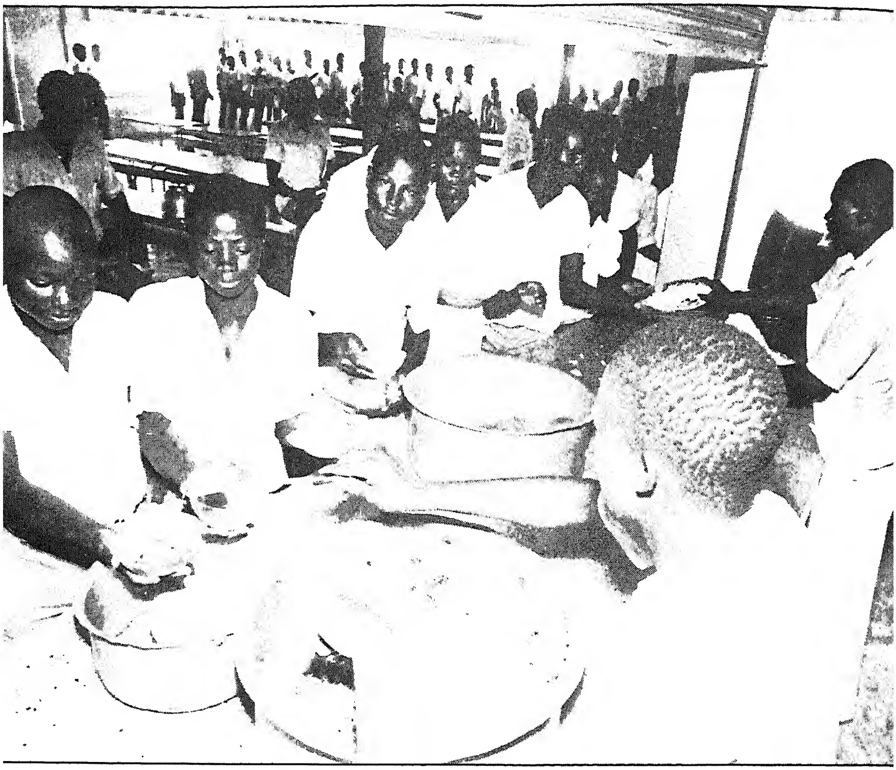
P.L. 480 also contribute to meeting the annual U.S. pledge to the Food Aid Convention of 4.47 million metric tons of wheat or other food grains.

Since the start of P.L. 480 programs, 290 million metric tons of commodities valued at $32 billion have been exported. Major commodities include wheat and wheat products, corn and corn products, sorghum, rice, nonfat dry milk, and soybean oil.

Although the volume of P.L. 480 exports relative to all U.S. agricultural exports has declined in recent years, P.L. 480 exports retain a considerable share of total exports for some commodities. During fiscal year 1979, P.L. 480 exports, as a percentage of all U.S. exports, were: wheat, 10 percent; wheat flour, 67 percent; rice, 18 percent; and soybean oil, 14 percent.

Three Programs

P.L. 480 authorizes three programs by which the United States can provide food aid.



In recent years, food donations have gone to 80 countries in Africa, Asia, and Latin America.

Under Title I, the U.S. Government provides loans to developing countries on concessional terms—low interest rates and long repayment terms—for purchasing U.S. agricultural commodities. Food supplied under Title I has been the largest component of P.L. 480 and has been used to meet all four legislative objectives in varying degrees.

The Title I program serves as an important mechanism to develop export markets for U.S. agricultural commodities. Although in some cases food aid can substitute for commercial exports, it is generally thought to contribute to larger commercial sales in the future, because of its contribution to economic growth and higher incomes in recipient countries. Moreover, because developing countries are expected to be among the largest growth markets for U.S. agricultural exports, Title I will retain its importance as a market development tool.

Among the countries which have "graduated" from Title I concessional sales to commercial status are Japan, Spain, Taiwan, Brazil, and most recently, Korea.

Since 1966, the Title I program has also increasingly emphasized its role of contributing to economic and agricultural development in recipient countries. The program supports de-

velopment in recipient countries by providing balance of payments relief, and by raising local currency when the recipient government sells the commodities on the local market. These funds are used for self-help development projects specified in each Title I agreement.

Forgiveness Factor

In 1977, Congress authorized a new "Food for Development" Title III program. Title III programs are similar to those of Title I, but provide for forgiveness of the original loan if the country uses the local currencies for programs in nutrition, health services, and population planning.

The Title III programs are multiyear—between three and five years—and targeted toward the poorest of the developing countries. Agreements thus far have been signed with the governments of Bangladesh, Bolivia, Egypt, Honduras, Senegal, and Sudan.

The other program authorized by P.L. 480, Title II, provides food donations to meet famine or other urgent relief needs, combat malnutrition, and promote economic and community development. Donations are made through U.S. private voluntary agencies such as CARE and Catholic Relief Services, through the World Food Program of the United Nations, and through government-to-government agreements.

A major priority for Title II donations is to help meet nutritional needs of vulnerable groups. Generally, programs emphasize mother-child health activities, but also include school feeding and food-for-work projects.

In recent years, annual food donations through Title II have gone to about 80 countries in Africa, Asia, and Latin America. Among the largest recipients have been India, Bangladesh, Egypt, and the Philippines.

Recent large-scale food shortages due to drought and refugee-related disasters have also resulted in unusually large requests for emergency food assistance, primarily in Somalia, Kampuchea, and Pakistan.

To complement its food aid programs, the United States now has a 4 million ton wheat reserve established in January 1981. The reserve was created to ensure that wheat would be available for use under the P.L. 480 program to meet urgent humanitarian food needs in developing countries, even if our domestic supplies are tight.

Up to 300,000 tons of the reserve may be used for unexpected emergency situations, when Congress cannot quickly appropriate additional money for P.L. 480. The reserve will help ensure that the United States can meet its annual pledge to the Food Aid Convention

Other Aid Programs

Although the United States was th first country to formally legislate a food aid program and remains the largest single donor, contributions other countries and international organizations have become increasingly important. The major interntional programs are the World Foc Program (WFP) and the International Emergency Food Reserve.

The WFP, a joint program sponsored by the General Assembly ar the Food and Agriculture Organiz tion (FAO) of the United Nations, operated since 1963. WFP is direc

by the Committee on Food Aid Policies and Programs, created after the 1974 World Food Conference to provide an international forum for consultation, discussion, and coordination of food aid.

Countries donate either commodities or cash to purchase commodities which WFP then distributes to developing countries for use in school lunch programs, mother-child feeding clinics, food-for-work projects, and other feeding programs. WFP also supplies food during emergencies.

The United States donates food aid to WFP under Title II. During the 1979-1980 biennium the U.S. contribution was $220 million, 30 percent of the actual commitments.

In recent years, a rising share of WFP's resources have been used to meet emergency situations, particularly needs of refugees and displaced persons. The International Emergency Food Reserve (IEFR) was created in 1976 to help respond to these emergencies and to allow WFP to continue uninterrupted its long-term development projects.

IEFR is administered by WFP and has established a reserve target of 500,000 tons. Contributions by individual countries are voluntary. The United States provided 125,000 tons in both 1978 and 1979, but during 1980 contributions reached 172,000 tons valued at $72.5 million.

Food aid from other donors, particularly the European Community (EC) and Japan, have increased recently, reflecting surpluses generated by their domestic agricultural policies. The EC is the second largest donor, contributing primarily wheat and dairy products. Contributions include bilaterial aid from individual countries and multilateral contributions funded by the EC Commission

Japanese food aid consists of rice, Japan's major domestic grain, whicl is either donated or sold on concessional terms. Canada and Australia provide primarily wheat as food aid Donations are made both bilaterall and through WFP.

Finland, Norway, Sweden, and Switzerland also regularly donate food aid to developing countries. Al though each country's contribution is small, relative to agricultural production it often is greater than that of the major donors.

What of The Future?

During the past three decades, com merical agricultural trade increasec substantially, while concessional foc assistance declined. In light of this situation, what is the future for foo assistance in times when surpluses are not available?

The United States provides an example of the conflicts involved. Competing claims on U.S. food supplies began to emerge in the earl 1970's as large agricultural exports reduced food supplies available for domestic use and contributed to higher food prices. At the same tim as the price of oil began to skyrocke commercial agricultural exports became increasingly important to the U.S. balance of payments.

These developments contributed t rises in the real cost of food aid. Bu developing countries' needs for aid also continued to increase as many were financially unable to meet the food requirments through commercial imports.

During such periods when the

Commitments and shipments of food aid in cereals, July-June

Donors	1980 FAC pledge	Shipments 1975/76	1976/77	1977/78	1978/79	1979/80	1980/81[1]
		1,000 tons					
Argentina	35	—	22	32	30	38	48
Australia	400	268	230	252	312	304	400
Austria	20	—	—	—	—	—	19
Canada	600	1,034	1,176	884	735	730	600
China	NP	—	12	68	3	25	(25)
EC[2]	1,650	928	1,131	1,374	1,159	1,205	1,650
Finland	20	25	33	47	9	14	20
India	NP	—	—	100	295	80	50
Japan	300	33	46	135	352	688	567
Norway	30	10	10	10	10	37	40
Saudi Arabia	NP	—	—	—	26	10	10
Spain	20	—	—	—	—	—	20
Sweden	40	47	122	104	104	98	90
Switzerland	27	35	33	32	32	32	27
Turkey	NP	—	20	13	5	5	10
United States	4,470	4,284	6,147	5,992	6,237	5,418	5,262[3]
WFP purchases	—	NA	63	57	72	22	(50)
Others	—	199	62	116	104	270	(165)
Total	7,592	6,863	9,107	9,216	9,485	8,976	9,053
U.S. share	58.9%	62.4%	67.5%	65.0%	65.8%	60.4%	58.1%

Source: *Food Outlook,* Food and Agriculture Organization (FAO), June 23, 1981.

1 Commitments or allocations.
2 European Community. Includes member states.
3 Includes supplemental appropriation of $142 million approved July 1980.

( ) Estimated.
NP — No pledge.
NA — Not available.
— No donation.
FAC — Food Aid Convention.
WFP — World Food Program.

world food supply-demand balance is tight, many countries—including the United States—are faced with tradeoffs among: 1) satisfying consumers at home, 2) meeting food needs in developing countries, and 3) fulfilling commercial export demand.

Commercial food trade will continue as the primary means of meeting world food needs, but countries have also pledged themselves, evidenced by the Food Aid Convention, to meet needs of developing countries through food aid.

Food aid can't solve the world's food problems. But it will stay a vital element in meeting shortrun, emergency food needs, and—where properly administered—in assistin the recipient country's economic a agricultural development.

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agricultural economics. Generations of students have returned to their homelands richer in practical skills.

Arranging for the training of foreigners has always been an element of the official U.S. assistance program, and USDA has long been active in agricultural training. Presently, USDA's Office of International Cooperation and Development (OICD) manages the "participant" or individual training program.

One dimension of this permanent assistance instrument is strictly academic: placing undergraduate and graduate students in suitable universities. For foreign civil servants, extension agents, and teachers, OICD organizes non-academic training consisting of study tours, on-job training, laboratory visits, seminars, and meetings with U.S. officials and international agencies.

AID and its predecessor agencies have contracted with USDA to bring over the bulk of the trainees. The numbers peaked in the mid-sixties; in 1967, AID was funding 1,244 training participants from the Near East and South Asia, 520 from the Far East, 417 from Latin America, and 179 from Africa.

AID PHOTO

A substantial portion of India's gain in crop production is due to U.S. transfer of agricultural knowledge to Indian farmers.

Subsequently, AID diverted resources to other activities, but there has been an upsurge of late, with 909 participants in 1980 steered to USDA's training division. The United Nations, foundations, and foreign governments sponsored more than 700 additional participants. In contrast to earlier generations, half the current class is African and half of the academic participants are graduate students.

USDA also cooperates with universities to conduct short courses in the agricultural sciences, open only to foreigners. In the last five years there has been an increase in the number of courses and the percentage conducted overseas.

The Department is only one of several institutions to manage the education of foreign agriculturists. Universities involved in projects abroad channel students to the United States and shape their course work.

Recently, consortia of universities have been active, particularly the Southeast Consortium for International Development centered in Georgia. There is also an upswing in the number of arrangements by private companies on behalf of foreign students.

Shirt Sleeve Teams

Americans dispatched to run projects day-to-day in foreign lands or to educate others to do the same are the most direct form of assistance this country affords. Where there are few human skills there is no substitute for dispatching a team of experienced and determined agriculturists.

"Shirt-sleeves diplomacy" was the term used to describe work of the agriculturists who organized the extension services in Latin America and brought Point Four around the world. Examples abound.

Howard Gabbert, director of the Point Four office in Costa Rica, launched a food production program that resulted by 1953 in establishment of 30 extension offices manned by Costa Rican agents. One result: Contour plowing became increasingly common in the country and a long history of soil erosion was reversed.

In neighboring Panama, meanwhile, Earl Rambo of the Arkansas Extension Service was instructing farmers in use of tractors, plows, seed drills, and combines. In Jordan, a Point Four team borrowed techniques developed in our western grazing States to build demonstration dikes useful in taming freshets that roar through the desert after rainstorms.

In Liberia, Frank Pinder was teaching villagers to grow rice in the inland swamps. During his travels he sold seeds for cocoa, coffee, and oil palm at the nominal price of two cents. Dubbed by Secretary of State Dean Acheson "a modern Johnny Appleseed," he planted other seeds by training Liberians to carry on the work.

These examples are typical of projects in agronomy, farm equipment, and irrigation. Waves of specialists also addressed technical problems in horticulture, entomology, animal husbandry, veterinary medicine, soil conservation, drainage, and crop storage.

Technical interventions don't necessarily affect the structure of a developing country's economy. In the last 25 years, impatience with the pace of development has moved aid

The American "land-grant idea" of transferring research findings to farmers is being adopted in many developing countries.

administrators to look to other, more permeating forms of assistance. However, the Point Four approach is still very much alive in agricultural missions that are part of larger programs. The Peace Corps and many voluntary organizations preserve whole the spirit of direct assistance.

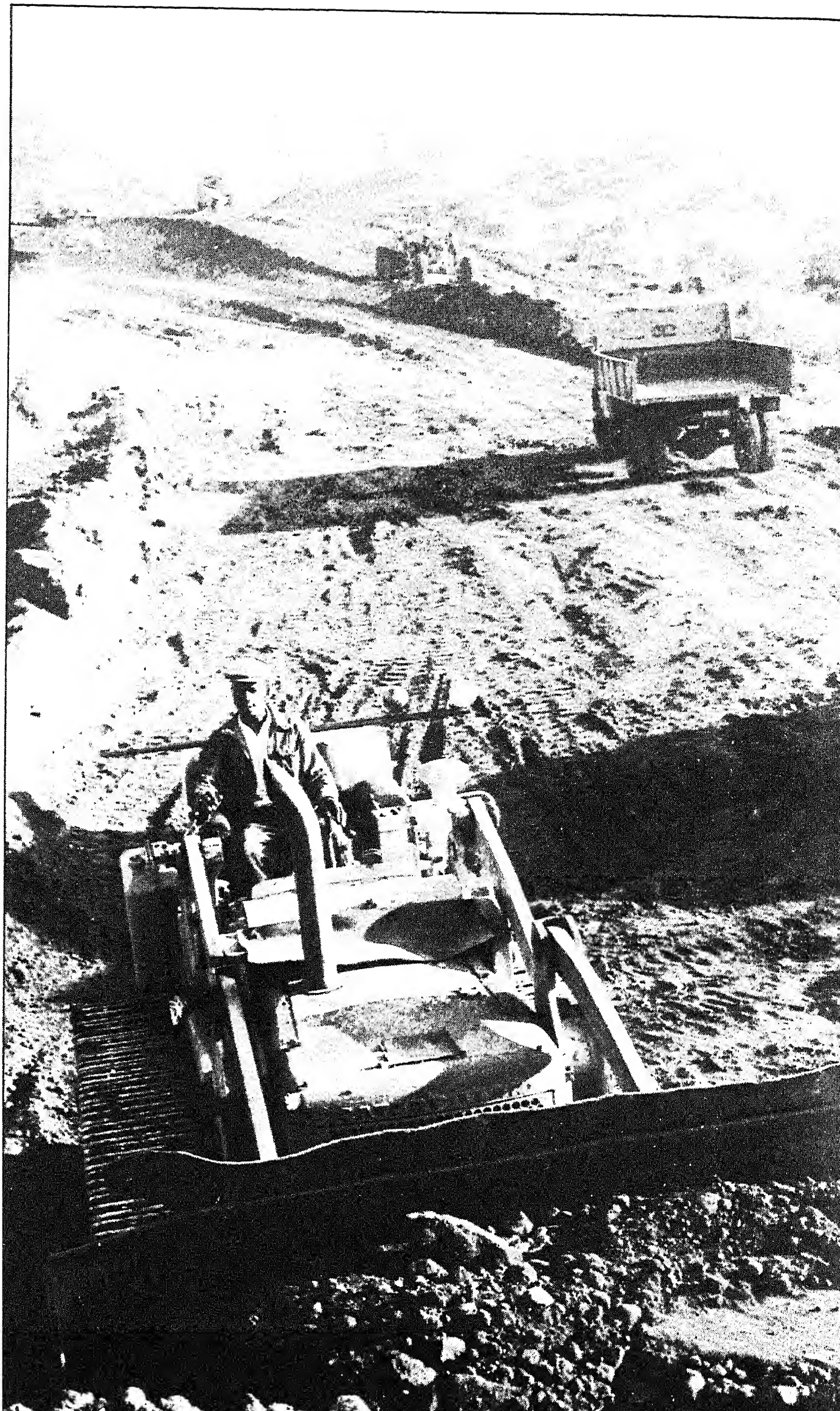
Building Ag Campuses

The "land-grant idea" has run through all U.S. efforts to establish permanent seats of agricultural progress in developing countries. A philosophy of public service, it charges the institutions responsible for maintaining and augmenting the store of scientific knowledge to work directly with farmers to solve problems encountered in the field.

In America the land-grant idea is embodied in a particular set of institutions: agricultural land-grant universities, State experiment stations, and extension services, all centered on USDA. These institutions combine the functions of classroom teaching experimentation and farmer education to guarantee that researchers respond to the needs of farmers.

In some countries representatives of American universities and their hosts have sought to transplant elements of this system. Brazil is a noteworthy example. Indeed, at Vicosa in the state of Minas Gerais there exists a near duplicate of an American land-grant college.

Vicosa dates back to the early part of the century when a professor from Florida State selected its rugged site, far from the cities but central to the farming district. After World War II, Purdue University began a long association with Vicosa. Through AID funds, Purdue helped organize schools of forestry, home economics,



JACK MOSS, AID

and agriculture. An extension service set up to complement the existing state service facilitated integration of research and teaching with farmer education.

Linkages with other institutions, many in contact with American schools, make Vicosa part of a national network aimed at improving agriculture. For example, the Agricultural Universities in Sao Paulo (Ohio State), Rio Grande do Sul (University of Wisconsin), and Ceara (University of Arizona).

It has not been necessary to duplicate the U.S. land-grant system in order to exploit the idea that motivates it. The mass of State Department-university contracts through the sixties provided for a wide variety of functions.

Michigan State, Kansas State, Wisconsin, and other universities forged links with five well-established Nigerian universities to build on work initiated by the British colonialists. American cooperation proved useful in drawing up agricultural plans, devising curricula, furthering existing research programs, and especially in training Nigerians to assume key academic positions.

In Thailand, Iowa State and the University of Kentucky currently are working in another way to enhance the country's ability to respond to farmer needs. They have cooperated with government agencies in setting up a statistical bureau to gather data needed to deal with policy questions such as pricing agricultural goods.

Loans from the Agency for International Development are used to construct market roads, irrigation projects and fertilizer plants.

Bankrolling Growth

Loans to finance construction of market roads in Columbia and Peru; installation of irrigation works, drainage pipes, and tubewells in Pakistan; or construction of a fertilizer processing plant in Jordan are typical of the capital assistance approach adopted generally by AID in the 1960's.

Although many agency-financed projects have had only indirect links to agriculture, the sort mentioned literally transformed the countryside in some areas. Their sophisticated nature added to the expense but also added markets for equipment produced by U.S. industry.

It is almost impossible to unravel the lines of inquiry responsible for global dissemination of modern scientific-based agriculture. We do know the ultimate source of the American contribution is the system of land-grant colleges and universities with USDA at the center. That benefits have spread to the international community is beyond dispute.

There is some question, however, whether the United States has exploited its capacity to go beyond training researchers to doing research on adapting key agricultural inputs to tropical and semi-tropical conditions that exist in most developing countries as well as in parts of the United States. Unlike institution building or capital transfers, this form of assistance has at times met congressional resistance. Through most of the sixties AID, which has had no research facilities of its own, operated under a directive that banned financing research on behalf of developing countries in competitive crops such as wheat, rice, tobacco,

sugar, vegetable oils, and cotton. This policy changed in 1968. In succeeding years AID became a key contributor to research through the network of international research centers in the Consultative Group on International Agricultural Research (see Dalrymple article).

Won Nobel Prize

These international centers date back to the early forties when the Rockefeller Foundation sent American agricultural scientists to Mexico to apply techniques of plant genetics and pathology, developed for the sake of Midwest farmers, to solving Mexico's grain production problems.

Future Nobel Prize winner Norman Borlaug and his Mexican associates made more than 30,000 wheat crossings to produce varieties resistant to local rust, varieties that utilize the same number of days to maturity regardless of whether the hours of daylight are lengthening or becoming shorter, and varieties that incorporate fertilizer responsiveness of the semi-drawf strands. The end product was a high yield, disease-resistant wheat, at home in many of the world's tropical zones.

A corps of 700 Mexican agricultural scientists trained by Americans in experiment stations and on Rockefeller Foundation scholarships in the United States inherited the entire Foundation enterprise in the early sixties. Today, under auspices of the Mexican-based international research center CIMMYT, they carry on the vital work of applied crop research.

A similar story groups the Ford and Rockefeller Foundations, Cornell University, the Philippines, and improved rice varieties. This research effort continues to prosper at the i ternational center IRRI at Los Bar

No official U.S. agency can clai credit for developing a research fa ity for tropical agriculture on a pa with CIMMYT or IRRI. However, many experiment stations established in Latin America in the 19 and 1950's are operated by the cou tries themselves to upgrade key e port crops.

USDA also has managed the Special Foreign Currency Researc Program. The 1954 Public Law 48 (P.L. 480) legislation authorized USDA to initiate research projects overseas on the strength of local currencies paid to the United Stat for the sale of surplus food. Scientists at USDA set to work designi and managing projects that complemented their own lines of inves tigation and also held potential benefits for the host country. Between 1958 and 1966, 29 countries shared 775 research grants.

Finns, Turks, Chileans

Typical projects have had Finnish scientists fighting the bark beetle, Turkish botanists cataloguing plan with possible industrial uses, and Chilean laboratory testing artifici light to stimulate growth response in pine cuttings.

Recently, with a shift in P.L. 480 repayment terms from local curren cies to dollars, the number of coun tries with excess local currency available for research purposes has declined. The program is still pursued in Egypt, India, and Pakistan

Research contribution of the uni versities to the developing world is evident whenever a "sister" institu tion conducts soil sample analysis, tests for the preferred level of pes-

cide application, or supervises a reeding program. Helping implant capacity to improve the use of esources and inputs is an integral art of institution building.

Of late the universities have aid increasing attention to another esearch service. AID legislation ncouraged collaborative projects etween the most qualified agricul-ural scientists in the United States, ational institutions in developing ountries, and the international esearch centers.

Congress eased the way by lifting he ceiling it had imposed in the 960's on the money AID could dis-ourse to researchers. Today, collab-orative research is slated in wheat, sorghum, millet, small ruminants, beans and cowpeas, pest manage-ment, and tropical soils.

An example of ongoing work is the joint wheat breeding program carried out by CIMMYT and Oregon State University. The dividends are im-proved genetic material for our Northwest as well as the tropics.

Another example is the two-year-old sorghum program. It involves a consortium of U.S. universities work-ing in laboratories and experiment stations in this country as well as on country projects in Africa.

Scientific knowledge now exists to beat back hunger not only in the United States but throughout the world. USDA, land-grant universi-ties, the experiment stations, State extension services, and private re-search foundations have an unsur-passed body of scientific knowledge and practical knowhow. We only need the political will to carry the weapons they provide to new fronts in the fight against hunger.

Someday we may be able to record successes relating to staples such as sorghum, millet, beans, and cassava that match the work in wheat and rice. The benefits to the productivity of U.S. agriculture promise to be sig-nificant. The impact on farm income and food consumption in poor tropical countries could well be crucial to the well-being of millions.

Going All-Out in India

The U.S. assistance effort in India spanned more than two decades. It drew on the many operational elements we have dis-cussed in this chapter. Its success can be attributed to a fusion of these elements.

Thirty years ago, newly independent India's population had begun to swell while prospects for opening new agricultural lands were limited. In many places the soil was exhausted: India used less fertilizer on its 320 million cultivable acres than Belgium did on its 2.5 million acres. Primitive methods meant deplorably low crop yields.

Against this background Frank Parker, once a USDA scientist and in 1953 a representative of the U.S. Department of State, came to India to lead the existing Point Four mission. He toured the country and drew two overriding conclusions: 1) loss of nutrients in

AID PHOTO

A specialist at the Punjab Agricultural University inspects experimental planting of a new variety of Ragi, a millet-like crop.

India inaugurated the Intensive Agricultural District Program in 1961. Farmers in at least one pilot district for each of India's 16 states learned to use a cluster of improved farm practices. Economists judged the effort a partial success. The program raised overall production but only took root among prosperous farmers.

In subsequent years, U.S. aid institutions approached Indian agriculture from a variety of angles. AID channeled funds into enlarging India's domestic fertilizer capacity. USDA's Agricultural Research Service managed the nearly 200 research projects financed in the mid-sixties out of P.L. 480 rupees. The bulk were in crop research, crop utilization, and entomology.

American universities continued to nurture many new agricultural universities staffed, in part, by Indian graduates returning from the United States. Ohio State was active in the important

Punjab region. Under an AID contract her sister institution, Punjab Agricultural University, received over $4 million for research and extension work, teaching, and demonstration projects aimed at motivating Punjab farmers.

The Punjab demonstrations sometimes attracted more than 12,000 farmers from all parts of the state. Farmers rained requests on the university's new soil sample facility. In 1968, 70,000 samples were tested to determine optimal fertilizer doses.

In 1965, India suffered a severe setback. A disastrous drought led people to think that despite technical advances in agriculture, India could not count on feeding its people. The United States provided massive food aid, but insisted that the government adopt price reforms, grant concessions to U.S. companies to build chemical fertilizer plants in India, and divert resources to agriculture. The government responded through the scheduled Five-Year Plan for 1966-71.

In essence, it combined a price system favorable to farmers and renewed commitment to the "package" approach with a campaign to replace indigenous improved Indian varieties with the light-insensitive and therefore adaptable "dwarf" Mexican and IRRI varieties. An unscheduled shipment of 18,000 tons of Mexican seed to supplement the 15,000 tons on hand in 1966 was the first step in meeting ambitious target production levels.

Indian research institutions accelerated development and propagation of hybrids for corn, sorghum, and millet. The Rice Research Institute at Orissa bred into a short season Taiwanese rice variety resistance to diseases common to the south of the subcontinent. The success of Indian researchers and policymakers was one reason for the optimism with which many greeted the seventies.

Stepped up fertilizer production kept pace with growing demand. Yields in the Punjab more than doubled in corn and wheat, although it remained true that most of the rewards accrued to wealthy farmers. Good weather in the early and late seventies and appropriate price and marketing policies enabled the government to amass stocks of food grains.

Poverty remained a general condition but for the first time since independence, India could claim self-sufficiency—at least for a time. To this day the high-yielding varieties have sustained their elevated yields as production methods continue to improve.

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Global Research Wins a Cigar—Spelled CGIAR

By Dana G. Dalrymple

Whether there will be enough food in the future in the developing nations depends in part on what is accomplished in agricultural research. Yields must be increased if food production is to keep up with or preferably exceed population growth, and if food costs are to be kept down. An increase in yields requires new and improved agricultural technologies. The main source of these technologies is organized agricultural research.

As important as research is to providing enough food, it has long been relatively neglected in the developing nations. Through most of history, increases in food production were principally obtained by enlarging the cultivated area. But as population expanded, the relative availability of land fell. Increased production had to come, in the main, from greater yields—a much more difficult task.

While some agricultural research had been carried out in many developing nations since the turn of the century, most of it was sponsored by colonial powers and directed to export crops. Research on food crops for domestic consumption received comparatively little attention. This neglect largely continued until the middle of the 20th century. With the breakup of colonial empires, and population growth, greater attention was given to expanding domestic food production.

At first, many assistance officials thought all that was needed was to transfer agricultural technology from developed nations. It was presumed the main need was for an organization to disseminate technology (an extension or outreach service). Experience soon demonstrated that this alone wouldn't work; technology developed for temperate zones was seldom usable in more tropical regions. Moreover, farm size, structure, and resources were quite different.

The only satisfactory answer was to devise agricultural technology specifically for the developing countries. This in turn meant establishing indigenous agricultural experiment/research stations. Scattered efforts to do so through the mid-1960's often had mixed results. Even where some excellent colleges of agriculture were developed, the research function played a relatively modest role. Few realized what it took to get a meaningful research program underway. Still, some promising beginnings were made, both at the national and international level.

Emergence of System

By the late 1960's, the various research activities began to bear fruit. They also began to coalesce into what was to become the framework of an international agricultural research system focused upon food needs of the developing nations.

There were three major components to this system:
1) international agricultural research centers (IARC's),
2) national research systems in

Agricultural research — a necessity to improved crop yields — has long been neglected in most developing countries.

developing nations, and 3) national systems in developed nations.

The IARC's were located in developing nations and usually served as the centerpiece of the system. They generated new and improved technology, drawing upon appropriate work elsewhere for use in the developing nations. While some of this technology could be used directly, generally it required further development and adaptation to local conditions. National research systems in developing nations were needed for this purpose. National systems in developed nations were a source of background information and more basic knowledge.

The three components of the system were, and are, bound together by informal agricultural research networks. These networks are often sponsored by the IARC's and in] may be an outgrowth of their in: national variety testing trials. T often center on commodities, but be broader in orientation. An ex: ple is the spring wheat research work. The centers provide impro germplasm (varieties) for testing and report on the results. From t activity, other information activi have been taken on such as publ ing international newsletters, sp soring conferences, and the like. The centers also organize trainin programs.

A significant result of the existence of the international system that the research worker focusin; improving developing nation pro tion is no longer alone. The work can draw, as appropriate, upon a world-wide body of knowledge an collaborators. This can make the: work much more efficient and productive. A synergistic effect is involved (the whole is greater than the sum of the parts).

13 Centers and Programs

The IARC's play a key role in thi system. As of 1981, there were 13 ternational centers and programs sponsored by the Consultative Gr on International Agricultural Research (CGIAR) and several other ternational centers outside of this group. Together, they cover nearly the major food commodities and ecological zones in the developing world.

While a wide range of activities are represented by these centers ε programs, they do share certain common characteristics. These rel principally to their international character: they are sponsored by ε

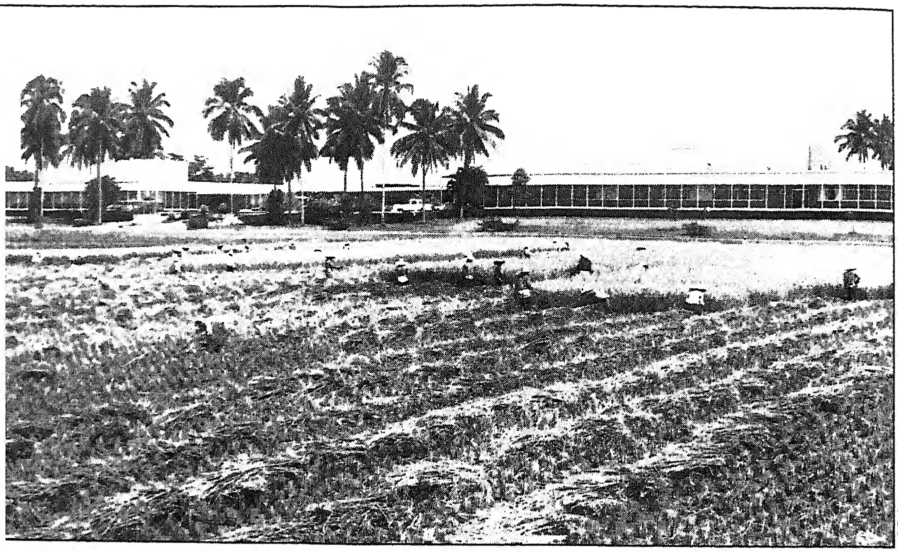
International Agricultural Research Centers and Programs Sponsored by the CGIAR*, 1981

Center and Program	Location	Established
Center:		
International Rice Research Institute	Philippines	1960
International Maize and Wheat Improvement Center	Mexico	1966
International Institute of Tropical Agriculture	Nigeria	1967
International Center for Tropical Agriculture	Colombia	1968
International Potato Center	Peru	1972
International Crops Research Institute for the Semi-Arid Tropics	India	1972
International Center for Research in Animal Diseases	Kenya	1974
International Livestock Center for Africa	Ethiopia	1974
International Center for Agricultural Research in the Dry Areas (desert areas)	Lebanon, Syria	1976
International Food Policy Research Institute	United States	1975
Program:		
West African Rice Development Association	Liberia	1971
International Board for Plant Genetic Resources	Italy	1973
International Service for National Agricultural Research	Netherlands	1979

*Consultative Group on International Agricultural Research.

number of donors of different types from around the world, and they have an international board of directors plus an international staff. Nearly all have international status in the country in which they are located (the International Food Policy Research Institute is, as of mid-1981, an exception). And all have at least a regional, and generally an international, commitment to assist developing nations.

The CGIAR, an informal affiliation of donors of many types, is the principal sponsoring group. Its principal purpose is to stimulate and coordi-



USDA

Workers harvest rice at the International Rice Research Institute in the Philippines, one of the first centers established to generate new and improved technology.

nate funding, and provide general guidance for the IARC's under its aegis. CGIAR was established in 1971 under sponsorship of the World Bank, the United Nations Development Program, and the Food and Agriculture Organization of the United Nations (FAO). It is serviced by a secretariat at the World Bank in Washington, and by a Technical Advisory Committee whose secretariat is located at FAO in Rome. The group is quite informal in nature compared to other international organizations.

As of mid-1981, CGIAR had 33 donor members. These included the international assistance agencies of 20 countries (including 4 developing nations), 4 foundations, 3 international organizations, and 6 regional organizations. Total contributions for core (basic) activities in 1981 were nearly $140 million. Several new donors are expected to join in 1982. Donors individually decide which centers and programs they are to sponsor.

The United States, through the Agency for International Development (AID), was a charter member of CGIAR. It has followed a policy of providing about 25 percent of the total core contributions. While this practice has made AID the largest single donor, the U.S. ranks considerably lower in terms of per capita contributions; it has consistently ranked 10th among the 16 or 17 developed nations in recent years.

Besides these core contributions to the centers, AID and other donors also sponsor special research projects in individual developing nations through their bilateral programs. A number of other AID-sponsored research projects are also tied into the international centers in various ways.

What of other food commodities? Man does not live by irrigated wheat and rice alone. Improved technologies developed by the centers for other crops are now finding their way into testing and use. Most are, however, unlikely to equal the extraordinary initial impact of the high-yielding varieties of wheat and rice. This is partly because the research base for other crops is substantially less: very little research has, for instance, been done on cassava (a tropical plant with a fleshy edible root). Also, the potential range of adoption is less: corn varieties, for example, must be developed for specific ecological areas; other crops are planted on more limited areas. The task, therefore, is difficult and often frustrating. Yet a promising start has been made.

Although the clear focus of the international centers and the international research system is on the developing nations, some of their products may also benefit the developed countries. The United States, for example, is now raising substantial areas of semi-dwarf wheat and rice (roughly 31 percent of the wheat area in 1979 and 12 percent of the rice area in 1980). Some varieties were imported from the developing nations and used directly, some were the offspring of developing nation varieties, and virtually all share a common ancestry. As the world's leading user of agricultural technology, the U.S. benefits from an expanded involvement in the international research network.

Three centers which are not members of CGAIR have fairly close ties to it. AID helped establish the first two (the Asian Vegetable Research and Development Center and the International Fertilizer Development Center) and is a significant contributor to each. It sponsors some projects at the third, the International Center for Insect Physiology and Ecology.

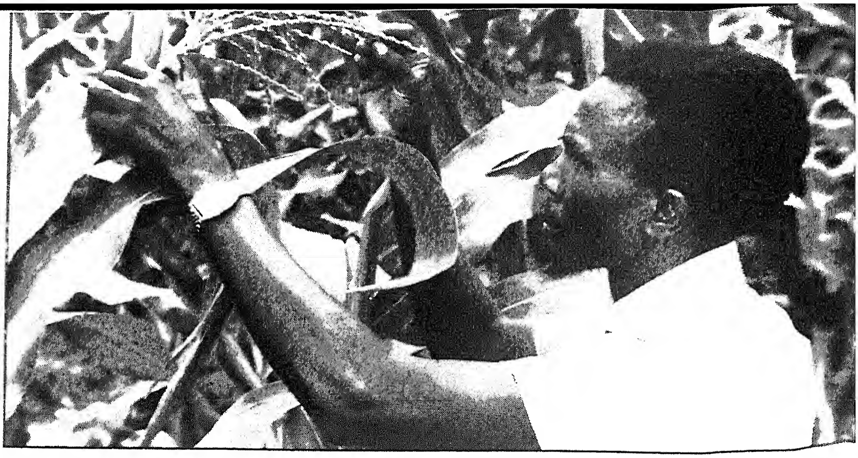
A few other regional research organizations also exist which have no particular ties to CGIAR. One of the most notable is CATIE (Centro Agronomico Tropical de Investigacion y Ensenanza) in Turrialba, Costa Rica.

Accomplishments

What has this comprehensive and imposing system contributed to the developing nations to date? The answer depends in part on the age and mandate of the individual centers. Roughly 10 years are needed to establish a center and get the initial research program underway to the point where improved technology is available for test in country programs. Another 5 years may be required for in-country adaptation and adoption. This is quite rapid compared to the history of most agricultural research systems in developed nations.

The two oldest centers, the International Rice Research Institute and the International Maize and Wheat Improvement Center, moved somewhat more rapidly than this general time pattern—partly because they were able to build on a significant research base and partly because their original technologies proved widely adaptable in their basic form.

The area planted to high-yielding wheat and rice varieties (principally semi-dwarf with short straw) developed by these centers and in related national programs is estimated



A Nigerian extension agent checks corn at the Gusau Demonstration Farm, a project financed by a loan from the World Bank.

to have grown from essentially zero acres in 1965/66 to about 135 million acres in the 1976/77 crop year. The latter figure represented slightly over a third of the total area planted to wheat and rice in the developing nations, an unparalleled rate of adoption.

Both the direct and indirect effects are significant. The higher yields made possible through adoption of these varieties and associated cultural practices, particularly increased fertilization, have resulted in an enormous contribution to increased food supplies in the developing nations. The supply increase has meant lower prices to consumers. There have also been important indirect contributions: the shorter growing season of these varieties, for example, has often made it possible to grow an additional crop each season—to carry out multiple cropping.

There have been, however, substantial gaps in the process. The original varieties were largely developed for irrigated conditions. Many important but ecologically less favored zones, such as those with more limited water supplies, often did not benefit. Greater attention is now given to developing technologies these regions and to better meet other needs.

Limitations of the System

The international agricultural re-search network is still relatively young. Both it and its component are still not fully developed, and have some limitations.

The IARC's are generally well organized, well housed, and well staffed. But they are of different ages and have quite different man dates. For these and other reason some have moved faster than oth in getting organized and getting going. All but the International C ter for Research in Animal Diseas are applied research organization they are not oriented to basic research. And at the applied end, they must rely on national system for field testing and further devel opment of the technologies they have generated.

Most developed countries (exclu ing Communist nations) both belo to CGIAR and have made efforts t increasingly tie their national sys tems into the international system A variety of approaches have been

age-old soils required a degree of fertilizer use precluded by high prices and the absence of a soil-testing program, and 2) separation of the established research and teaching institutions from the state extension arm undercut possibilities for improved cultivation.

India, unlike most poor countries, possessed ingredients of a land-grant type system, but desperately needed to integrate them in a way that moved teachers to teach practical agriculture and researchers to seek solutions to practical problems.

Indian agriculturists responded. One wrote that Parker's analysis provided the impetus to overcome stagnation. As the government cut fertilizer prices, Parker, with an Indian team, visited American campuses in search of land-grant "apostles." Soon six universities had answered the call.

Erven Long, leader of a group from the University of Tennessee, remembers the mid-and-late 1950's as a time of tremendous excitement and great working harmony among American agriculturists in India. Representatives of State Department agencies, USDA, the universities, and the Rockefeller Foundation all followed Parker's lead and strategy.

Long himself stayed in Banglore State in the south of India for five years. He organized the Agricultural College at Mysore around research on cultivation of *ragi*, a millet-like staple well adapted to that water-poor region. By using demonstration plots he was able to convince skeptical farmers that with the proper application of fertilizer, an improved variety of *ragi*—developed some time before by Indian scientists—outstripped traditional varieties whatever the level of rainfall.

A subsequent campaign to arrange credit for small farmers in the area cleared the way for near complete use of the improved variety within three years. Yields doubled, increased straw helped pay for the fertilizer, and the agricultural school gained prominence. This episode involved matching new inputs with staple food grains, a theme that pervaded the later course of development.

Another theme emerged through an alliance between the Indian government and a group from the Ford Foundation under the chairmanship of Sherman Johnson. An experimental program was built around the assumption that increased use of one input alone yields limited results, that gains in production agriculture depend on a skillful combination of inputs. Johnson also argued that this "package" approach was only practicable in a country like India if confined to areas where production potential is high and the water supply assured.

Americans Pitch In to Fight World Hunger

By D. Feinstein, R. Nightingale, and C. Hanrahan

In 1979 India weathered a drought without importing grain. On its face this accomplishment seems modest. For those familiar with the country's history it is a staggering achievement. Fifteen years ago, India's plight was considered hopeless, its population of 500 million prey to inevitable cycles of starvation and misery. Through the late 1960's and the 1970's the population grew to over 600 million; and yet, to the astonishment of many, India's farmers began to produce large surpluses. The government gradually amassed stocks of wheat and rice that in hard times would provide some margin of safety to the poor.

Fifteen years ago the United States pumped into India an unprecedented cargo of food aid. Subsequently we accelerated the transfer of agricultural knowledge to the Indian farmer. The campaign took many paths, all in the direction of increasing the production of food. The measure of our assistance program's success is the magnitude of India's revival.

The U.S. effort to share with poor, developing countries the scientific methods that account for our abundant harvests did not begin, nor has it ended, with India. Direct country-to-country assistance has been part of American foreign policy since World War II. With the success of the Marshall Plan in Europe, President Truman launched the Point Four program to spread benefits of American technology to every continent

From the outset the State Depa ment's assistance arm—the Agen for International Development (A and its predecessor agencies in th 1940's and 1950's—have relied on services of agriculturists in the U Department of Agriculture (USD the land-grant colleges and unive sities, the foundation and volunta organizations.

Over the years these institutio have doggedly fought world hung adopting varied and innovative a proaches. The repertoire includes training, technical assistance, institution building, capital financi and research. These tools tell the of U.S. agricultural assistance.

Students from Abroad

The sustained increase in produc ity of America's farmers is due in large part to an educational syst that maintains, expands, and disseminates the store of technical knowledge. The system is most closely identified with the teachi research, and extension functions of the land-grant colleges and universities.

By the turn of the century, lan grant schools attracted students f around the world. Often under th auspices of private groups, such the Institute of International Edu tion, foreign nationals enrolled in university departments of plant s ence, agricultural engineering, fo estry, soil science, animal industr

Many States have produced buyer guides and other product information material for food importers abroad. States are particularly effective in supporting food processors because marketing officials generally have close contact with the companies in their States.

FAS also is involved directly in export promotion, but each activity is designed to support companies interested in exporting farm products.

FAS activities include export credit programs, overseas exhibits and trade fairs, sales teams to selected foreign buyer markets, and product label clearances in key markets (a host of regulations on additives, weights, dating, etc., are involved in selling processed foods to almost every market). Activities also include a trade opportunity referral service where overseas buyers are put into contact with U.S. exporters by a computer matching program, and a program called *CONTACTS* that informs overseas buyers of the availability of products and companies interested in exporting these products.

Export credits are an important USDA tool to help move additional farm products. Various laws approving several types of credit are on the books, but currently the major emphasis is on a credit guarantee program. Under the guarantee program, commercial banks extend a credit line for six months to three years to purchase U.S. farm products, and the U.S. Department of Agriculture (USDA) guarantees the bank that the credit will be repaid.

$2.3 Billion in Guarantees

This approach allows banks to extend credit to countries beyond normal country limits and makes additiona credit available to finance farm exports. In fiscal year 1981, a total of $2.3 billion in credit guarantees was available for helping to financ agricultural exports.

Other credit programs, currently not funded, include a direct credit line from the Commodity Credit Co poration for up to three years, an intermediate-term credit program (3 to 10 years) to finance breeding livestock overseas, facilities to aid in expanding U.S. farm sales, to meet credit competition from other countries and, in the event of an in ternational grain reserve, to help countries finance holding of grain stocks.

All of the credit programs are designed to stimulate interest on the part of overseas buyers in usin additional U.S. farm products.

Frequently, credit programs hav helped introduce new agriculture products in overseas markets. In t early 1960's Japan was granted a li of credit for grain sorghum. The U Feed Grains Council worked with Japanese feed manufacturers to incorporate grain sorghum into livestock rations. As a result of th combination of credit and technica servicing, Japan became and remains a steady consumer of U.S grain sorghum.

Sales Teams

To promote processed foods in mar kets too small for a full-size exhib FAS works with marketing officia in State departments of agricultu to set up sales teams. Five to eigh companies with noncompeting

ing country or U.S. officials.

Care must be taken while compiling the export shipping papers. Failure to obtain or accurately complete the appropriate papers may result in rejection of the shipment or fines at the foreign port.

Ocean Transportation

Export documents serve as proof that exporters have complied with terms of the sales agreement. An export invoice, for example, often indicates the buyer's product specifications have been satisfied. Evidence that orders have been moved from port facilities and placed on ocean vessels is provided by ocean bills of lading.

Agricultural exporters who ship relatively small orders of commodities abroad transport goods on common carriers, which are regulated by law and adhere to regular shipping schedules and published freight tariffs. There are two types of common carriers: conference and nonconference vessels.

Conference carriers belong to organizations known as shipping conferences, each of which consists of companies whose vessels depart from one specific area of the world and serve another particular region. All members of a conference charge the same fees and comply with standard rules and regulations.

Contracts may be signed with conferences which entitle exporters to reduced freight rates. These contracts, however, bind exporters to use of conference vessels when shipping to the area the conference serves.

Not all common carriers belong to shipping conferences. A small number of independent liners, known as nonconference vessels, also follow set shipping prodecures. They travel the same routes as conference carriers, but compete with conference vessels in service and price. Although freight tariffs of nonconference carriers are often lower than those of conference vessels, their visits to U.S. ports are less frequent.

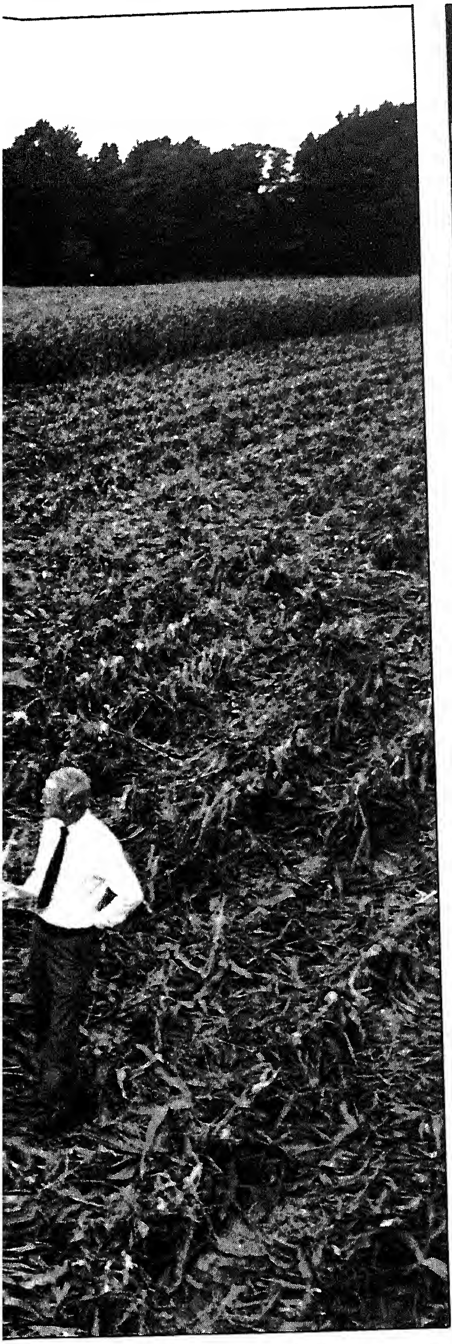
Tramp Carriers

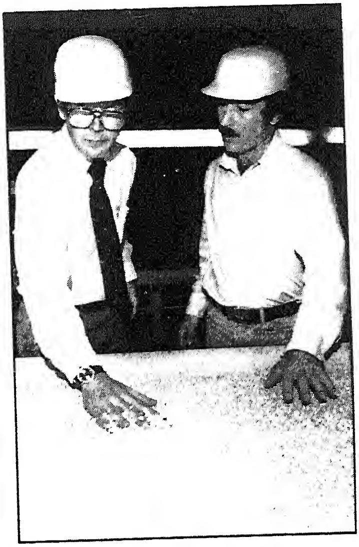
A third type of ocean vessel on which agricultural orders are transported abroad are private or "tramp" carriers. Exporters of bulk commodities or those who ship orders big enough to fill entire vessels are major charterers of these carriers.

Tramp vessels don't keep regular schedules, charge relatively fixed freight rates, or travel set routes. Instead, each time an exporter hires a tramp carrier, he signs a freight agreement with the vessel's owner.

Details and freight tariffs of each freight agreement differ. Destinations, validity period, and the other charter terms are largely determined by the exporter's needs. Freight rates fluctuate frequently.

Loading commodities on common or private ocean vessels often ends the exporter's responsibilities. Although the exporter may hold title to the goods until they arrive at the foreign port, the buyer usually sees that the order is unloaded and cleared through customs. Sometimes customers refuse to accept the shipments. Such cases occasionally occur when market prices fall and the buyer can get less expensive goods elsewhere. This often forces the exporter to reduce his price and divert the shipment to another customer.





Howard looks over sweet corn prior to canning with William Teat, vice president, KMC Food Inc., Queen Anne, Md.

Richard Marks, Paris Foods, Trappe, Md., goes over export order of frozen carrots with Howard.

Bernie's Dilemma: How to Export My Products?

By Daleen D. Richmond

Bernie Anderson was tired. It was 11 o'clock on a Friday night and Bernie was still struggling with the dilemma that had troubled him all week. His produce sales were declining.

For many years, Bernie had been supplying grocers in the New York City area with increasing amounts of apples, oranges, lettuce, broccoli and other fresh fruits and vegetables. Recent reductions in the number and incomes of consumers, however, had hurt Bernie's business. Prospects were not bright.

Bernie slumped in his office chair and fell into a restless sleep. He dreamed that his suppliers were chasing him around the world demanding payment for their products.

Everywhere Bernie fled, however, he noticed that people were consuming his commodities. Tourists in the Bahamas were eating his grapefruit for breakfast, English royalty were sweetening their tea with his lemons, and Japanese housewives cried as they sliced his onions into their vegetable dishes. Bernie awoke just as he was surrounded at the Eiffel Tower. For the first time in many days, he smiled. Perhaps he should investigate the feasibility of exporting his produce.

A number of questions immediately popped into Bernie's mind. What types of firms export agricultural commodities from the United States? Where are the markets and who are the buyers for my products? What must I do to sell goods abroad? Are there companies that will help? How will my transactions differ from those of exporters who sell other commodities?

Bernie looked at his watch. It was 2 a.m. With an impish grin, he picked up the phone and began asking questions. Here are some of the answers.

Types of Exporters

A company doesn't have to deal with foreign buyers or perform many export functions to be classed as an "exporter." A firm that hires or sells goods to another company that carries out exporting responsibilities is known as an indirect exporter. For example, a farmer who sells his grain to a local elevator owned by Continental Grain Company is an indirect exporter if Continental Grain ships the grain to customers abroad.

Direct exporters typically come to mind when the word "exporter" is mentioned. They perform the majority of export functions in international transactions. Continental Grain Company, Cargill Inc., Sunkist Growers, Chilewich Corporation, Welch's Foods, and Seald-Sweet Growers are examples of companies that directly export agricultural commodities from the United States.

It is difficult to draw a general picture of direct exporters. Annual sales volumes of these firms range from thousands to billions of dollars. Besides, their ownership structures are diverse. Cooperative, private, and

taken and the progress is somewhat uneven. It is an area where the United States could usefully give more attention, both to better help others and for our own benefit.

On the developing country end, a major problem is the limited stage of development of many national systems, especially in Africa. A number of assistance organizations, including the Agency for International Development and the World Bank, have given high priority to improving these systems, but there is a long way to go. And when the research system is established, there is often difficulty in obtaining sufficient funds for its effective operation (a problem also shared in some developed nations).

The importance of stimulating development of national systems has long been recognized by CGIAR, many of whose centers were called upon to assist national systems. The difficulty was to develop an appropriate approach. In the late 1970's, CGIAR established an International Service for National Agricultural Research; it is now becoming operative.

In a related development, the directors of research institutions in the developing nations have organized themselves into an International Federation of Agricultural Research Directors and may be expected to provide further impetus for developing national systems.

Challenges

On balance, a most promising international agricultural research system is emerging. The principal focus is on food crops in developing nations. The various components are somewhat unevenly developed as yet, and linkages among the various components may be inadequate in some cases. But the significant fact is that the essential elements are in place. The principal need now is for adequate financial nourishment. With it, the system will be able to provide the technological basis for further expansion in food supplies.

Unfortunately, funding may be a problem in the near future. Besides the usual problems of obtaining adequate appropriations for research, inflation has created special difficulties. The costs of running agricultural research establishments, along with many other enterprises, has increased at a far faster rate than the availability of public funding. This is true of both the international centers and the national research stations. Until the supply and demand for funds come into better balance, research will stagnate or decline.

Agricultural research involves a fairly long lead time. If we are concerned about whether there will be enough food in the developing nations in the future, we must be concerned with the state of agricultural research in and for the developing nations. We must build today for tomorrow. Much has been accomplishe in recent years, more than at any time in history. The challenge in the next few years will be to maintain and if possible enhance the momentum of the research system we have nearly in hand.

Dana G. Dalrymple is an agricultural economist with the Office of International Cooperation and Development, U.S. Department of Agriculture. He is on detail to the Office of Agriculture, Bureau for Science and Technology, U.S. Agency for International Development.

Why U.N. Food Agencies Are Important to Us All

By Martin Kriesberg

The American people are not alone in their concern about world food problems or in seeking to remedy the situation facing hundreds of millions in low income, food deficit countries. International organizations are playing an increasingly important role in efforts to overcome hunger and malnutrition among the world's poor.

The World Food Conference convened by the United Nations in November 1974 gave added impetus to efforts by international organizations. Receiving increased resources from their member governments, these institutions are allocating a growing proportion of the resources to problems of food, agriculture, and rural development.

Most of the international organizations providing assistance to low income countries are autonomous bodies associated with the United Nations system.

FAO (Food and Agriculture Organization of the United Nations), established in 1945, is the largest organization devoted mainly to problems of increasing food production, improving its distribution and consumption, and raising living standards among rural people. FAO now has 147 member countries and is headquartered in Rome, Italy.

FAO provides technical assistance and training in all aspects of food and agricultural development. It holds periodic meetings to deal with specific commodity problems or more general problems such as food security. FAO collects, analyzes, and disseminates a wide range of data on food, agriculture, and rural development. Its technical and scientific reports have a worldwide audience.

Types of Funding

Two categories of funding are available to FAO: The assessed (quota budget) contributions by member countries, and extrabudgetary funding provided by the United Nations Development Program, the World Bank, and voluntary contributions by national governments. Most voluntary contributions and contracts with the other international agencies are for assistance to developing countries. For the two-year biennium 1980-81, FAO's quota budget was $278 million and other fundings aggregated almost $500 million.

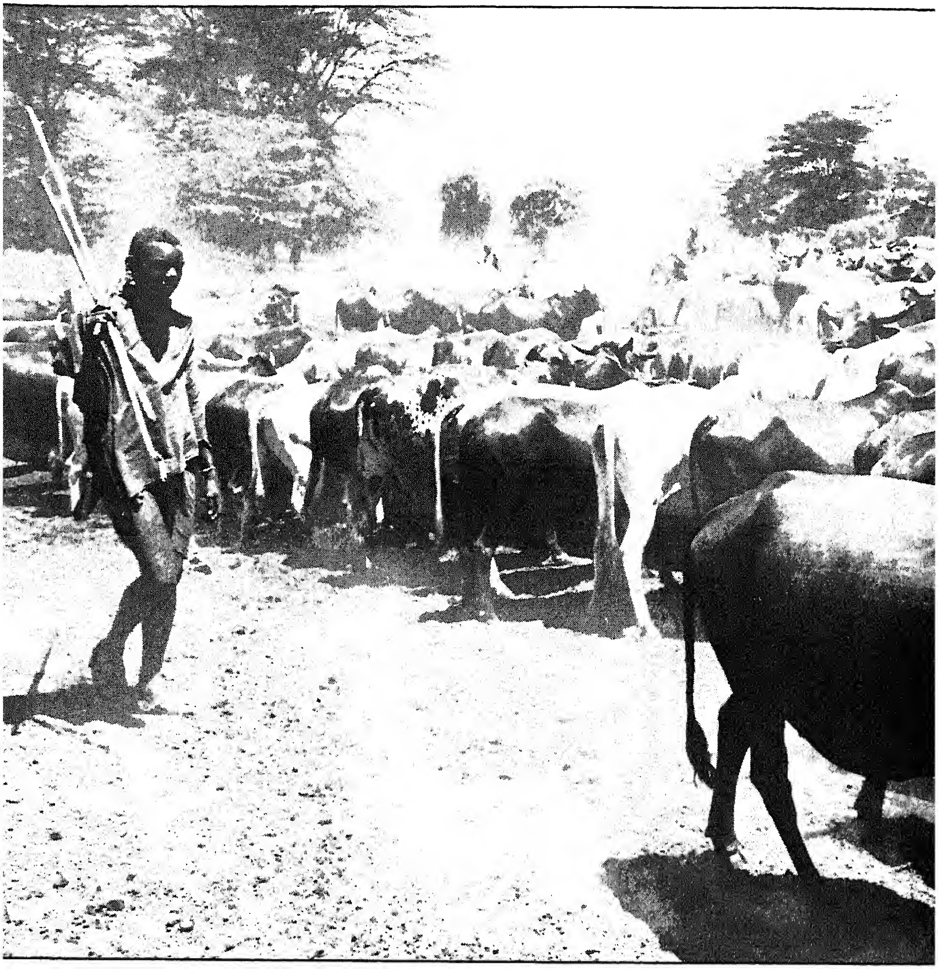
WFC (World Food Council) is one of the new international bodies established as a result of the World Food Conference of 1974. WFC seeks to monitor and coordinate followup activities based on resolutions promulgated by the conference. WFC provides neither financial nor technical assistance. It convenes an annual meeting at the Ministerial level to assess the world food situation and to recommend policies and actions by national and international agencies to improve conditions—particularly for low-income, food deficit countries. Funding for WFC comes directly from the U.N. system; there are no other country assessments or contributions.

The Food and Agriculture Organization, headquartered in Rome, has 147 member countries.

UNDP (United Nations Development Program), headquartered in New York, is the hub of technical assistance activities of the U.N. system. UNDP develops five-year development programs in cooperation with aid-receiving countries. As individual projects are formulated within this framework, it requests one or more specialized agencies within the U.N. system to execute the project. UNDP reimburses the agencies for their work. FAO serves as the executing agency for most projects in food and agriculture initiated by UNDP.

UNDP is supported largely through voluntary contributions of member countries. In 1979, a total of $681 million was contributed by 136 member countries, with additional fundings for recently added programs that UNDP administers. Recipient countries pay in local currencies about 60 percent of the project cost. The United States contribution in 1979 was 18 percent of that year's total.

UNDP projects include: 1) surveys of natural resources that may be developed; 2) stimulating capital investment, based on the surveys;

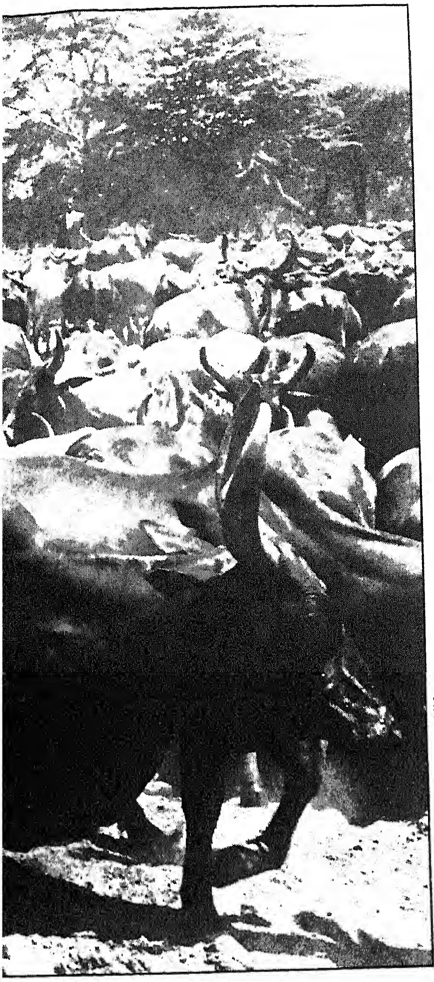


In Kenya, funds from the International Development Association help develop a long-term program to increase beef production by pastoral groups such as the Masai.

3) providing professional and vocational training; 4) adapting modern technology to projects in agriculture, health, education, and industry; 5) helping formulate overall economic development plans.

IBRD (International Bank for Reconstruction and Development—the World Bank group) consists of three institutions. They are the World Bank, the International Development Association (IDA), and the International Finance Corporation (IFC). They share the common purpose of providing and promoting a flow of capital into productive projects in developing countries. However, they function in different ways:

■ IBRD makes long-term loans at conventional interest rates.



JAMES PICKERELL, WORLD BANK

■ IDA makes loans to the poorer developing countries on very concessional terms.

■ IFC facilitates the flow of private capital for investment in private enterprises in developing countries.

The World Bank group comprises, by far, the largest source of development assistance on concessional terms. An increasingly large proportion of the loans go to agriculture and rural development projects. During each of the past three years, IDA provided over $1 billion in agriculture credits—40 percent of its total commitments. Overall, the World Bank made new commitments to agriculture and rural development projects of about $3 billion during each of these years.

At the most recent (1979) agreement for replenishing IDA resources, the U.S. share for this arm of the World Bank declined to less than 30 percent.

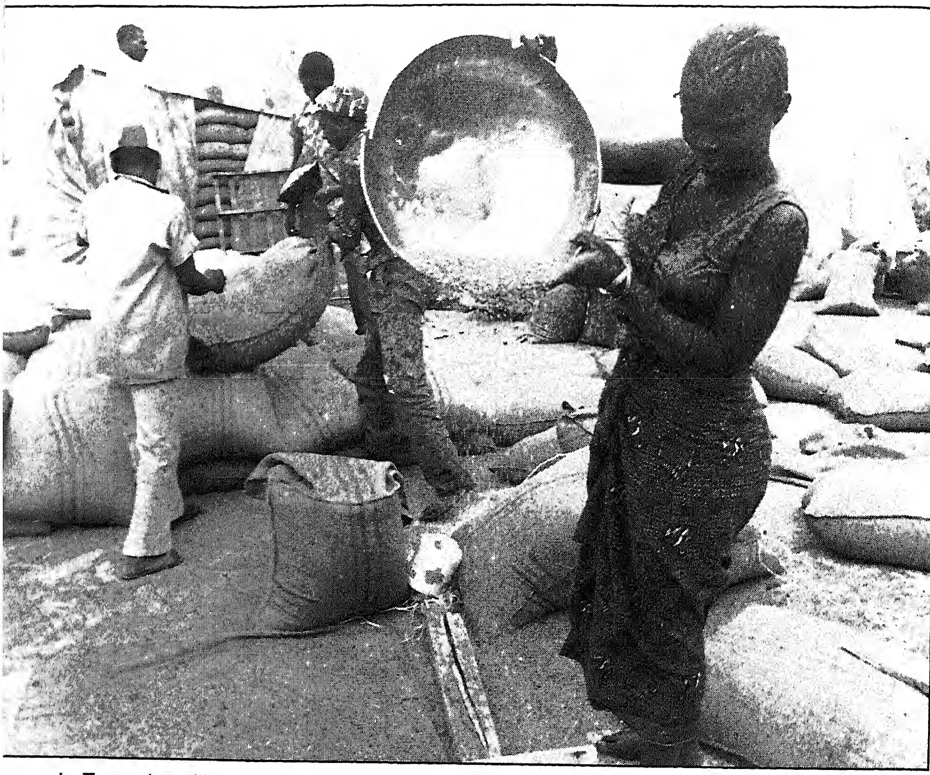
The United States has subscribed to 23 percent of the World Bank's capital stock, but is required to pay in only 10 percent of the amount subscribed, that is, about 2.3 percent of the bank's total capitalization. The remainder is callable in event of need.

Because the bank borrows in the world's capital markets—up to the level of its subscription—for funds it lends, the United States actually pays in only about 2 percent of the bank's regular loans.

Other international organizations contributing importantly to food and agricultural development in low income countries include:

■ IFAD (International Fund For Agricultural Development); a new U.N. agency established pursuant to resolutions of the World Food Conference. Its original funding of $1 billion is directed toward the poorer developing countries and the smalle producers.

■ WFP (World Food Program) is a joint undertaking of FAO and the U.N.; it provides food aid for development, humanitarian, and emergency needs. The United State contributes about 10 percent of its


F. MATTIOLI, FAO

In Tanzania, millet is sieved before storage at a major warehouse at Dodoma. FAO experts are helping the Government build a national grain reserve.

overall Public Law 480 or Food-for-Peace resources to support WFP activities.

■ IICA (International Institute for Cooperation on Agriculture) is an arm of the Organization of American States and directs its technical assistance and training activities to improve agriculture and the conditions of rural life among Latin American and Caribbean countries.

■ Regional Development Banks for Asia, Africa, Latin America and the Caribbean operate like the World Bank, with both concessional loans (and grants) for specific projects in accordance with developing country needs. All have made agriculture and rural development a major part of their lending commitments.

■ Other U.N. Agencies such as the World Health Organization (WHO), the U.N. Children's Fund (UNICEF), and the U.N. Environment Program (UNEP) also contribute to the world's ability to feed itself. WHO is particularly concerned with health and nutrition; it collaborates with FAO on codes and standards to facilitate trade and to assure quality foods. UNICEF is especially involved in food and nutrition problems of infants and children. UNEP, a relatively new U.N. effort,

is concerned with the environmental impact of economic activities and with conserving resources to assure their productive capacity for the years ahead.

Benefits to the U.S.

The United States, as well as the countries receiving aid, benefits directly from the international organizations working to improve the food and agriculture situation in developing countries.

The U.S. people and government recognize a moral responsibility for assisting peoples and countries who need help for short-term emergencies and long-term development. While generous and compassionate, the United States is also concerned that the burden of aid be borne equitably within the international community.

Since all governments contribute to the international organizations according to their capability and/or on a voluntary basis, the U.S. share in these organizations has declined as other country economies have grown. The United States now contributes 25 percent to most of U.N. agencies; it provides a much smaller proportion of funds for the World Bank and the regional development banks of Asia and Africa.

The American people and the national economy benefit by the purchase of U.S. goods and services arising from membership in the international organizations. When the World Bank and regional development banks make loans to developing countries, most of it goes for purchases of goods and services from the United States and other industrialized countries. Organizations like UNDP and FAO hire U.S. nationals for regular staff positions and for scores of short term consulting assignments.

But more importantly, as the developing countries are assisted to strengthen their economies, they become better markets for U.S. goods—especially foods. Developing countries now account for almost 40 percent of total U.S. agricultural exports (and this proportion is growing). Moreover, improved economic conditions in developing countries also contribute to political stability and moderate governments.

Forums for Policies

International organizations like the World Food Council, FAO, and the World Food Program (with its governing body, the Committee on Food Aid Policies and Programs), provide opportunities for U.S. officials to explain U.S. policies and the ways these policies and our kind of food systems may achieve higher levels of production and consumption. Where international action is needed, these forums help the United States gain acceptance for a line of action compatible with U.S. interests and world needs.

Because so large a portion of the U.S. agricultural economy depends on exports, good working relationships with other governments and an understanding of how their food and agriculture systems operate are essential to optimize U.S. marketings.

Moreover, during recent years when many developing countries have sought significant changes in the terms of trade for their commodities and a basic change in the economic order to favor them more, the international organizations have provided opportunities for useful dialogues. The forums have been

useful to moderate differences and to permit accommodations on both sides.

International organizations such as FAO and the World Bank collect, analyze, and distribute to member countries a great deal of useful data on food and nutrition, agriculture, and rural life.

U.S. scientists and agriculturalists exchange technical information with colleagues in FAO, the regional development banks, and others worldwide, through information and workshops organized by these international agencies and through collegiate interchanges. The USDA agricultural report, *World Fertilizer Situation,* for example, relies heavily on FAO statistics and data for its projections for fertilizer consumption and production as well as determining the price of fertilizer components.

U.S. participation in FAO's computerized International Agriculture Research Information System facilitates access to timely and comprehensive information of the world's agricultural literature. Also, FAO is the only body carrying on global fishery studies and data services; U.S. access to this service provides useful information which would be difficult to obtain otherwise. Recently, FAO reinstituted a survey of fiber production and consumption. This was sought by U.S. cotton and textile interests.

Protecting Plants, Animals

International organizations—such as FAO, the OAS' International Institute for Cooperation on Agriculture, and the U.N. Environment Program —are engaged in efforts to improve soil and water management, achieve a more balanced use of forest lands and fishing waters, prevent deserti fication, and protect animals and plants against desert locusts, the Mediterranean fruit fly, African swine fever, foot and mouth disease and other plant and animal enemi These efforts complement U.S. programs.

A noteworthy example is FAO's quick and vigorous efforts to contr outbreaks of African swine fever i Central and South America where this deadly virus killed millions of pigs in 1978 and 1979. IICA, with the cooperation of Haiti, the Unite States, and other nearby countries now engaged in seeking eradicatio of the disease from Haiti. Preventi spread of this disease is of particu importance to the United States' $8.5 billion hog industry.

Participating in international o ganizations sometimes poses problems for the United States. Most U.N. agencies comprise 140-150 sovereign governments. Each has somewhat different perception of t world and how its own interests might be advanced by the interna tional body. The large majority of member countries are poor—by co parison with the U.S. and other i dustrialized countries like Japan, Germany, and Sweden. Most poor countries, as a group or bloc, seek use the machinery of the U.N. sys tem to improve their economic co tions, and some of their proposals seem wrong and unacceptable to t United States.

There is also considerable misu derstanding about the nature and functioning of the U.N. system. T United Nations General Assembl and Security Council at the U.N. headquarters in New York are oft engaged in political debates and p

resolutions that the United States sometimes opposes. But these actions are distinct and apart from the activities of the autonomous specialized agencies such as FAO, the World Food Program, and the International Fund for Agricultural Development, which devote themselves to technical aspects of improving the world food situation. The World Bank and the regional development banks, also, carry on their operations with little involvement in political issues.

As the preeminent world power in matters of food and agriculture, the United States has played a leading role in the work of the international organizations concerned with improving world food production and consumption. While the U.S. has been a principal provider of resources for the international organizations, it also has been a principal beneficiary.

Within the U.S. Government, many agencies are involved in U.S. relations with the international organizations discussed here—particularly the Department of State, the Department of Agriculture, and the Agency for International Development. The Treasury Department is also involved, particularly in U.S. liaison with the international development banks. An interagency working group which meets regularly helps assure that all interests are represented and that the United States follows consistent policies in all the international forums.


MARY SEBRECHTS

Hogs are checked for African swine fever in Haiti where the U.S. is helping eradicate the disease.

Further Reading

Evaluation and Future Outlook for Aid to Agricultural Development in Developing Countries and for Food Aid, Organization for Economic Cooperation and Development; Chateau de la Muette; 2, Rue Andre-Pascal; 75775 Paris 16, France. Free.

International Organizations and Agricultural Development, FAER 131, U.S. Department of Agriculture, OICD/IOA, Room 6552-S, Washington, DC 20250. Free.

Meeting Food Needs in the Developing World, International Food Policy Research Institute, 1776 Massachusetts Avenue, N.W., Washington, DC 20036. Free.

Martin Kriesberg is Deputy Administrator, Office of International Cooperation and Development, and Coordinator, International Organization Affairs, USDA.

Poor Nations Prosper, U.S. Picks Up Customers

v A.B. Mackie, T.L. Vollrath, and L.C. Cesal

t's a fact of life you can't buy anything without having money, credit, · something else to give in exıange. So it is with nations.

Developed and well-to-do nations ade much more than less prosperıs countries. Each community in a eveloping country tends to be selfıfficient, and trade lags—even nong regions. Every step up in deelopment increases domestic and ıternational trade. So actual and otential trade among countries deends on the level of their income.

World economic growth in recent ears has greatly increased internaonal trade, in both farm and inustrial products. Economic growth as given consumers more purchasıg power, and appetites for foods not idely grown in their countries.

In the developing nations, people's eeds and desires for more food and a etter quality diet generally have not een satisfied by domestic producon. Food imports, therefore, have een increased to keep pace with the rowth in consumer incomes and deıand for food products. Thus, rising emand for food, as well as greater iversity of consumption, has led to surge in international trade in ırm products.

Illustrating the importance of this ıcreased trade to the American ırmer, from 1975 to 1980 U.S. farmrs exported about a third of their orn and nearly 60 percent of their heat. The stake of the American ırmer in world agricultural development and economic growth i big indeed. Expansion in export markets has become a key elemer U.S. farm policy in the 1970's anc will no doubt remain a central feature in the decade ahead.

Shift in Foreign Demand

Historically, the high income developed countries provided the m markets for U.S. farm exports. H ever, these nations now have con sumers who are becoming quite satisfied. The majority of their pe have large enough incomes to adequately fill their food needs.

Moreover, as their incomes clir still further, they are likely to sp proportionately less on food. And population growth in developed c tries has dropped sharply so that accounts for but a small part of t world's growth in demand for foo

Developing countries, however, be expected to take an increasin share of the world's growing dem for food. Over the coming decade this will be the result of rapid gr in population and expected rises in per capita income and food consumption.

The high-income, developed co tries currently account for about 60 percent of all U.S. farm expoı While exports to these countries have been growing in recent yea the expansion has been primaril feed products and high-value foo products such as fruits. Exports food grains such as wheat and ri have gone up only slightly.

Future expansion of U.S. farm exports to high-income countries will come primarily from increases in population and shifts in consumer demand to higher quality foods such as meats and animal products. These consumer shifts are predictable and usually result in growing imports of feeds and feedgrains used to produce livestock, and thereby affect commodity composition as well as the rate of growth in import demand.

Low-income developing countries currently account for about 30 percent of all U.S. agricultural exports. Most of the growth in their demand for U.S. exports has been for food grains.

Acceleration Seen

Growth in total demand for food in the developing countries can be expected to accelerate greatly as per capita income rises because the relatively poor people in these countries spend a large part of their income on food.

Income growth in the developing countries usually causes total demand for food to go up faster than domestic producers can satisfy it, thus boosting the demand for food imports. About 90 percent of the world's population growth is taking place in developing countries. So not only will the demand for food imports go up because of rising incomes, but also due to the large increase in the number of people to be fed.

A recent U.S. Department of Agriculture (USDA) study shows that with a 10 percent per capita income rise in high-income countries (countries with per capita income of more than $700 per year), farm imports from the United States increase only 2 percent. But in low-income countries (nations with less than $400 per capita income) they jump nearly 16 percent when per capita income goes up 10 percent.

Recent experience has borne out implications of the USDA study. According to the Food and Agriculture Organization (FAO), from 1967-79 the developed nations increased their total volume of imports of agricultural products from all countries by 40 percent. The developing countries increased their volume by 108 percent. In terms of value, the imports climbed 14.4 percent a year in developing countries but only 13.3 percent per year in developed nations.

Foreign economic growth and agricultural development is important to the American farmer. An examination of 14 selected countries, with average annual growth rates in farm output substantially greater than in the United States, shows that economic growth increased consumer income levels to the extent that their present imports of U.S. farm products are an average of 1,643 percent greater than in 1954-55.

There are large potential markets for U.S. farm products in the developing countries of Latin America, Asia, and Africa. But if these countries are to become effective commercial markets, they must achieve higher levels

In China, rice hulls are processed and bagged for use as animal feed. China hopes to increase meat production and could emerge as an important customer for U.S. farm products.

of economic growth—most likely associated with higher levels of agricultural development, enabling them to pay for additional farm imports.

Farming Is the Key

In developing countries 80 to 90 percent of the population lives in rural areas. Thus, a large part of the labor force, often representing the most abundant resource available to the country, is directly or indirectly linked to farming. Effective mobilization of this human resource through employment is essential to economic growth.

In the early development stage of these countries the farm sector accounts for most of the economic activity. So increasing the productivity of this sector significantly expands overall economic activity. This can be done by introducing modern fertilizers, pesticides, and high yielding varietal seed.

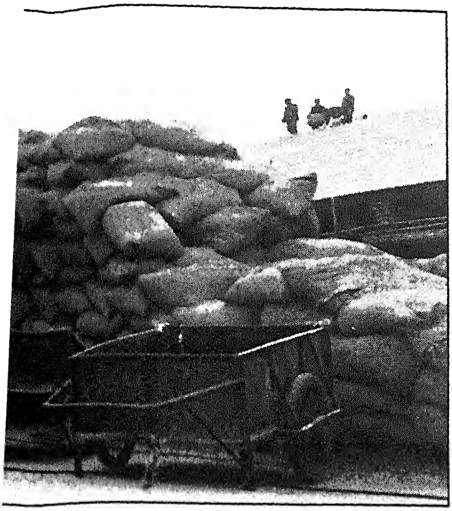
Nonfarm economic activity is ver limited and thus there are few oppo tunities for hiring wage-labor outsic of farming. A significant part of th effort to increase per capita income must be focused on people who gair their livelihood in agriculture.

Since per capita income is low, th average family devotes most of it tc buying food and can't afford to buy nonessentials. Thus, the demand fo food, a primary need, is much great than the demand for products from domestic nonfarm industry.

These conditions that dominate tl low-income countries mean that agricultural development plays a significant role in the economic growtl process. Hence, the main focus of initiatives to accelerate economic growth in most of the countries sho be on agricultural development.

Stimulating Growth

Viewed in the context of general economic expansion, agricultural



JAMES C. WEBSTER

can be grown by domestic farmers or imported.

Agricultural development stimulates productive linkages between different sectors of the economy. It generates more rural income which is used both to buy nonfarm inputs to boost agricultural production and to purchase nonfarm consumption goods. This stimulates industrial growth.

Moreover, it promotes growth in other sectors of the economy by releasing labor from agriculture for employment elsewhere. Increases in farm productivity permit fewer resources to be used for producing a given level of farm output.

development stimulates economic growth in several ways. First, it increases the output of farm products needed to meet a country's growing food needs.

In early stages of development, when per capita income is low, increases in the total demand for food are primarily a result of population growth. Rising incomes, improved health facilities, and a desire for improved nutrition essentially assure that population growth will remain high in the foreseeable future.

As countries move from the low-income to the high-income development stage there is a marked rise in demand for high quality food. This is due to shifting from primary reliance on foodgrains and staples to increased consumption of high protein animal products.

Since production of animal products requires large amounts of feedgrains, there is a significant jump in demand for grains that

Leads to Investments

Another contribution is through increasing the supply of domestic savings. In early development stages, income from farming is greater than that from other areas. A part of this is transferred in the form of capital to nonfarm sectors where it is used tc finance investments in infrastructure, manufacturing, educational facilities, and other government services essential to promotion of overall economic growth.

Finally, development of agricultur may result in larger exports of farn products, thereby earning foreign e: change that can be used to increase imports. In all countries certain items, including some farm commodities, can be imported more cheaply than they can be produced domestically. Thus, agricultural de velopment often makes it possible f a country to acquire less expensive consumer goods from abroad. Also may permit importing of capital ir puts needed for industrial expansi

In developing countries, most of the labor force is linked to agriculture.

Highly successful development of agriculture in other countries, Japan and Korea for example, is often accompanied by increased U.S. exports of agricultural commodities to those countries.

These discussions show that U.S. farm exports climb as economic growth in other countries transforms them from low-income to high-income nations. Agricultural development plays a vital role in fostering economic growth in the low-income countries. Thus, through trade linkage, prosperity of the American farmer is directly related to agricultural development and economic growth in other nations.

Most countries can't achieve a high level of economic and social development on the shaky foundations of rural stagnation and poverty. Such conditions exist in many of the less developed countries today where most of the people live and make their living by farming.

The Issue of Competition

Frequently, the issue of foreign agricultural development and U.S. farm exports become confused with questions of competition for existing markets.

Short-run competitive relationships do arise and will always exist. However, this is not nearly as serious with the low-income developing countries as it is with the high-income developed countries where production tends to parallel that of the United States.

In any event, the interest of American farmers is to expand the total world market by enhancing the ability of more countries to import U.S. farm commodities.

Given a large and rapidly expanding world market for food, U.S. agriculture can find opportunities to adjust production patterns and expand total export sales. It is in working for this larger pie, rather than for a slightly larger piece of a shrinking pie, that the American farmer's economic interests are best served.

Policymakers have not ignored the importance of promoting foreign agricultural development as a means of expanding potential markets for U.S. farm commodities.They have recognized that in the longer term the United States can sell its farm products only to those who can pay for them.

In the past this has usually meant the people in the richer nations. However, with the foreign aid programs in the postwar years, including the Food for Peace Program and Public Law 480, U.S. exports of food products to developing countries have increased greatly. Korea and Japan are two countries that provide good examples of how our assistance has helped other countries become paying customers.

During the early 1950's the United States provided these two countries with development assistance. In 1980 American farmers sold them $7.9 billion of farm commodities.

Many other countries have been major recipients of U.S. economic and technical assistance; a number have graduated from the need for such aid. Because their economic growth has been more rapid, they have increased their imports of U.S. farm products more than the average for all of the developing countries.

It is this potential for continuous, long-term expansion of the world

During the 1950's, Japan and Korea were large recipients of food assistance programs. Today they are among our best customers, purchasing almost $8 billion in farm commodities.

market for agricultural products that answers the question: "What is the economic interest of American farmers in the U.S. foreign aid program?"

Further Reading

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ection Six

ooking Ahead

TIM MCCABE

Enough Food? Sure, If We Don't Play It Dumb

By Don Paarlberg

Pessimism has arisen about the ability of the earth to feed its people. Burgeoning population growth, rising enery costs, doubts about the adequacy of the agricultural resource base, pre-emption of a disproportionate share of available food by the well-to-do, allegations that discovery of new agricultural knowledge is lagging, and misgivings about weather in the years ahead are cited in outlining a dismal food prospect for the poor people of the world.

A parallel form of pessimism has arisen regarding ability of American agriculture to meet the demands likely to be laid upon it. No one doubts that our farmers will be able to satisfy the food needs of domestic consumers; concern arises about our ability to meet the projected needs of other countries.

The generally-accepted view is that between now and the year 1985, U.S. exports of agricultural products will have to expand 5 to 8 percent a year. This would mean that by the mid-Eighties the United States could be exporting 175 million tons of grains and oilseeds, compared with 80 million in the early Seventies.

Can this be done? Doubters warn that it may be difficult, or that it can be accomplished only with a sharp increase in the real price of farm products, or that it cannot be done at all. Here are some of the cited obstacles:

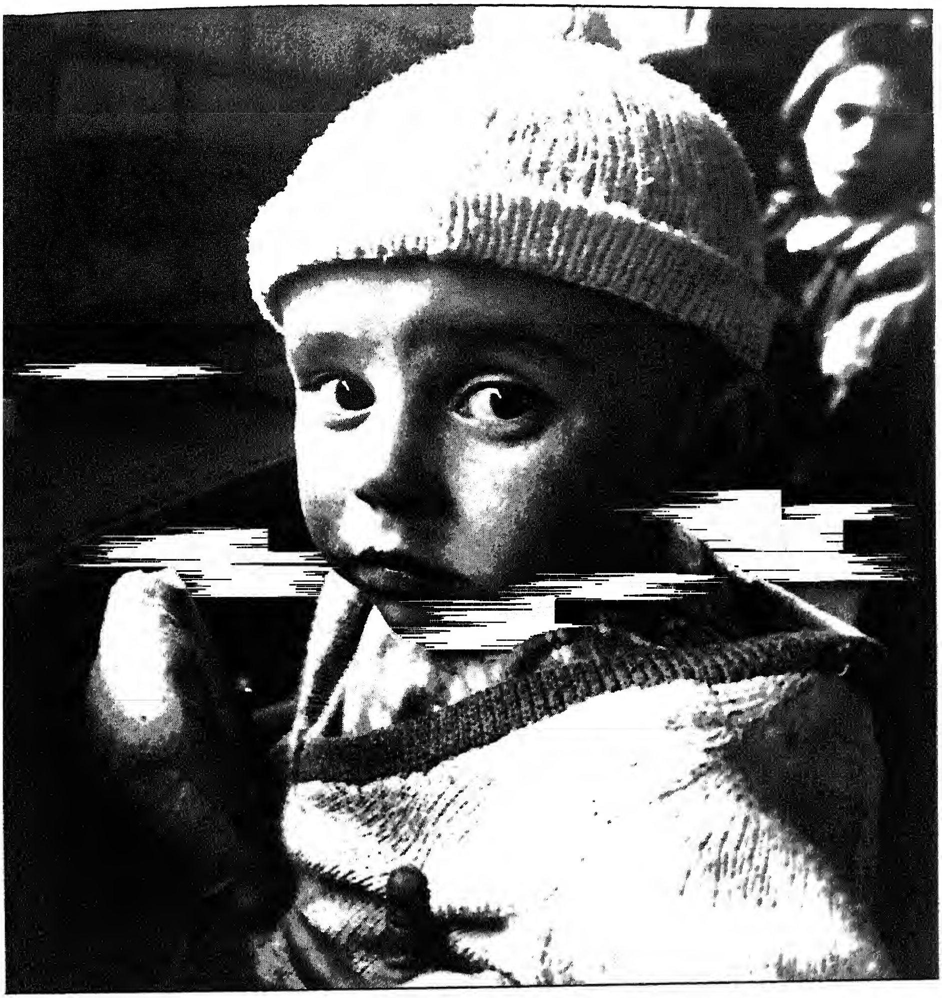
- Our retired acres are in use; the reserve we formerly had is n committed.
- Cropland is being lost to ur banization and to erosion.
- The gasohol program—if implemented—would require by 1990 the production of from 15 to million acres, about 5 percent of our farmland.
- Research inputs are said to lagging and no new breakthroug are foreseen.
- Weather for the years ahead projected to be less favorable tha weather we have exerienced in th past.
- High energy costs, depleted groundwater supplies, and tough vironmental restrictions are said limit our production capability.

All told the conventional appra makes a dreary outlook so far as world food needs are concerned. O viewed from a different perspectiv it can be seen as the prospect for tighter food supplies and higher incomes for American farmers.

Institution Views

This appraisal is shared, in greate or less degree, by an impressive group of institutions: the Food and Agriculture Organization of the United Nations (FAO), the World Food Council, the International Food Policy Research Institute, the World Bank, the Overseas Development Council, and the Worldwatch Institute.

The assessment is explicit or implicit in a number of recent reports



Although hunger still plagues many throughout the world, the child death rate has dropped and the average lifespan is lengthening.

The Global 2000 Report, the Report of the Presidential Commission on World Hunger, and the Report of the Brandt Commission.

There have been pessimistic appraisals of the world food situation in the past: a neo-Malthusian food scare shortly after World War II; another

in 1964-65 with the poor crop in South Asia; another, much worse, in 1966-67, when drought struck India.

There is the recent memory of the world food alarm during 1972-75, associated with poor crops in a number of countries.

At the time these episodes appeared to most analysts to be unfortunate departures from normal. The prospective situation, as it is popularly perceived, has in it more of a continuing element.

The current assessment of tight prospective food supplies is the most remarkable in that it replaces an opposite view, which generally prevailed for the 40 years from 1933 to 1973. The dominant appraisal at that time was that we had excess agricultural capacity and that American agriculture was so structured as to overproduce, more or less on a continuous basis. Elaborate theoretical explanations were offered to support that view.

This chapter will assess the new mind-set oriented toward shortage rather than surplus. I call this perception "the scarcity syndrome."

Problem Diminishes

First, let's look at the world food situation. To many people who never missed a meal except by choice the precarious nature of the world's food economy is a new and frightening discovery. They have only recently come to learn of it, chiefly by television.

Actually, hunger is as old as history. The world literally lives from hand to mouth, never more than one crop away from hunger. The persistent and ancient fact of hunger shows how deep the problem is.

Objectively viewed, the world foo problem is diminishing. Consider these facts, agreed to by practically all who have studied the matter closely.

The average lifespan is lengthening, even in the poorest countries. I 1960, life expectancy at birth in the low-income countries was 42 years. By 1978 it had risen to 50 years. Somehow people had been able to obtain the food needed to lengthen their lifespan by 8 years.

The child death rate is dropping. In the low-income countries the death rate among children in the 1 to 4 bracket declined from 30 per thousand in 1960 to 20 per thousan in 1978. These recently-born childre were getting the food and health ca that increased the survival rate by percent during a period of 18 years.

Birthrate Decline

By dint of education, improved livin levels, social change, and public programs, the birth rate is coming down. In low-income countries the crude birth rate in 1960 was 48 per thousand; by 1978 it had fallen to 39

With the decline in the birth rate the rate of increase in population ha begun to taper off. During the mid-Sixties the world population was growing at a rate of about 2.0 perce per year; an estimate of the current rate is about 1.8 percent.

Average per capita food productio in the less developed countries has crept irregularly upward during the past quarter century. By 1979, a poo year, it stood at 105 percent of the 1961-65 level. Food production in th

Bangladesh has the potential to greatly increase its rice production.

[illegible] WORLD BANK

less developed countries has kept a half-step ahead of population growth.

The astounding fact is that per capita food production in the less developed countries moves irregularly upward, almost without regard to whether the public perception is that of surplus or shortage. There are slight deviations, resulting from good and poor crops. But for the 25 years of record the improving trend is clear.

Only about half the world's tillable acreage is in cultivation. True, the potentially tillable acres are less well-suited to agriculture than those now in use. They are more remote. Development would take enormous investment and much time. The acres we now use were not developed in painless fashion; we should not be disheartened by the fact that new development will also be costly.

Bangladesh, India

There is opportunity for increased food production in the developing countries. Bangladesh, though well endowed agriculturally, has a rice yield per acre only half as great as South Korea, which is less favored by nature. Improvements are coming about. India, written off by the Paddocks in 1967 as being beyond hope was a grain exporter in 1980.

New agricultural knowledge is being generated. Annual expenses for publicly-supported agricultural research have increased worldwide, in real terms, more than five-fold since 1951, and three-fold since the early 1960's. Almost everywhere, agricultural production is increasing by different rates from different levels.

Ten percent of the world's population receive less food than they need for good bodily health.

The developing countries are learning to meet the food needs of their poor people. Experience is being gained with fair price shops and food-for-work, giving hope that those on the lower rungs of the income ladder may share more fully in expanded food production

Overall production has increased for non-agricultural output as well as for farm products. The average per capita rate of growth in real gross national product in the low-income countries was 1.6 percent annually from 1960 to 1968.

The projected need for increased food imports in the developing world, much of which is expected to come from the United States, results not from any diminution in average per capita food production there. It comes from the fact that the anticipated increase in average per capita food production is less than the increase that would be necessary to satisfy the greater per capita demand. The greater per capita demand is the happy result of rising living levels in the low-income countries.

The projections show there will be a larger amount of food in the average person's bowl, but not as much more as his better economic circumstances would appear to warrant. Attention has become focused on the limited size of the increase, which has been labeled a shortfall.

Scourges Restrained

The twin scourges, hunger and disease, have been so restrained as to make inappropriate the high birth rate that earlier had been necessary. The still-high birth rate produces the rapid population increase, which does indeed lay a heavy responsibility on agriculture.

Question: Would the world prefer :he earlier condition, with high mor- :ality so limiting the population as to ɔlace no real challenge on agricul- :ure? Not likely. Everywhere the ɔeople have opted for what they con- ;ider the preferred problem, feeding :he more numerous individuals ʌho now survive.

None of this recitation is intended :o gloss over a world food situation vhich is and always has been pre- :arious. Averages are deceptive. The 'ood situation is grave indeed for the nany millions whose incomes and 'ood intakes are far below average.

According to the FAO there are ome 450 million people, 10 percent ›f the world's population, who receive ess food than they need for good bod- ly health. Many millions have such ow incomes that they would not get nough food even if production were ;reatly increased. There are whole .reas, particularly some African ountries, in which per capita food ›roduction is declining.

The important point remains: the ʌorld food situation, though precari- us, is not worse than it was; it is etter. Our heightened perception of he problem makes it appear worse.

Consider the past. A study at Ìanking University revealed that :om 108 B.C. to 1911 A.D. there were ,828 famines in China, or nearly one ɔmewhere every year. Between the ears 10 and 1846 A.D. there were 01 famines in the British Isles.

In the Western World the scourge f famine has been defeated. In the ɔw income countries it has been riven back but not defeated. There ave been recent famines in Biafra, .ampuchea, Ethiopia, Ogaden, and imor. These were more the result of war and civil disorder than failure of agriculture.

Not only is the world food situation improving; there is the prospect that it will improve further. There are, in place or in prospect, the institutions and the knowledge that, if used wisely, would permit the world to escape hunger during the lifetime of people now living.

Can U.S. Fill Needs?

Can American agriculture meet the demands likely to be made on it? Can we meet the increased needs of grain-for-food, grain-for-feed, grain-for-export, and grain-for-gasohol, all at the same time?

First, let's look at the demand side. The gasohol program is likely to be cut back severely, thus reducing the anticipated draft on grain supplies. The new Administration has rescinded $505 million of the $525 million in loans authorized by the previous Administration.

Per capita consumption of red meat, after increasing rapidly, appears to have stabilized at around 190 pounds. Cattle and hogs now carry less finish than they once did, requiring less grain per pound of meat.

The export demand on us may be less than projected. New acreage may be brought in by Brazil, Thailand, the Sudan, and other nations. After many years of inept agricultural policy Argentina may "get her act together" and make good use of her great potential.

If the real price of grain rises, production will increase in these coun-

One of the most serious problems facing American agriculture is loss of productive soil due to mismanagement of the land.

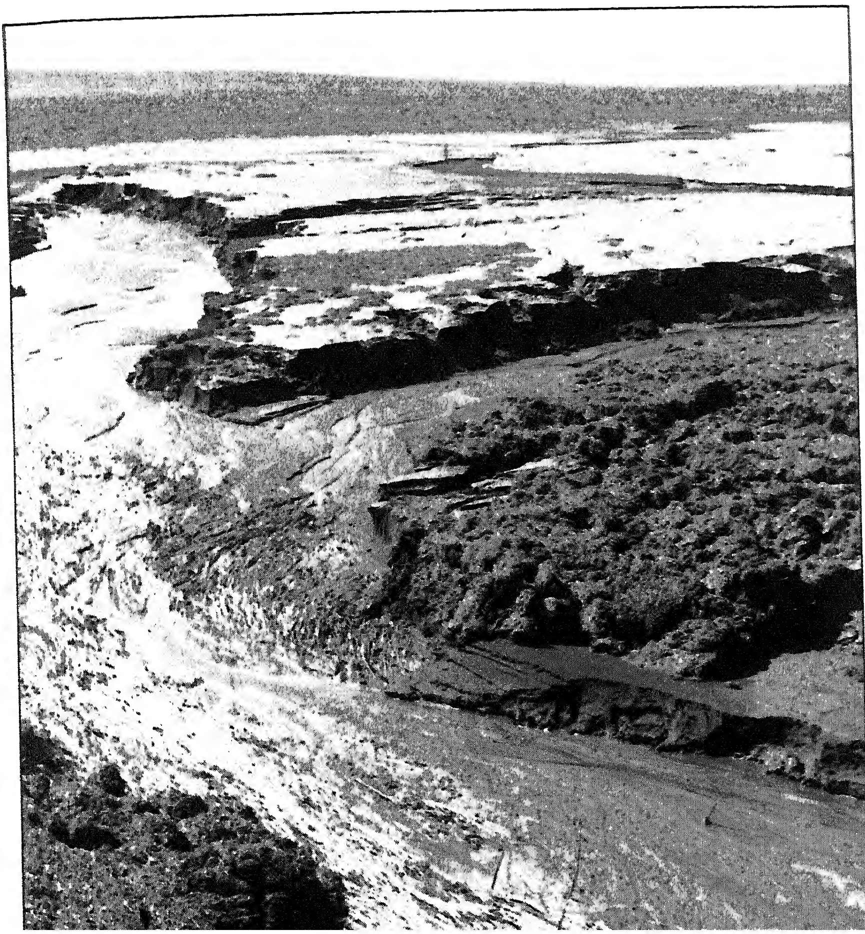
tries, as well as in the United States. Deputy Secretary of Agriculture Dick Lyng says that if the price of eggs rises high enough even the roosters begin to lay.

Now let's look at our production capability. As to our land resource, the National Agricultural Lands Study reports there are 127 million acres of potential cropland in the United States, besides the 413 million now in use. True, these additional acres are more erosive and less productive than those now cultivated. But with modern conservation tillage they could be made productive.

Loss Tally Disputed

We often hear that 3 million acres of farmland are being lost annually to urban uses. This figure is four times too high. It includes range, pasture, desert, mountain, forest and other areas not used for crops.

The correct figure is 675,000 acres, two-tenths of one percent of our cropland. This is enough to cause adjustment problems in particular local areas but not enough to jeopardize our overall food production. People who think we are approaching maximum use of our farmland should visit Japan or Western Europe and see what is possible.



TOM POZARNSKY

The erosion problem is more serious. Our huge modern machinery is ill-suited to the small fields, terraces, contour tillage and grassed waterways appropriate to soil conservation. So fences are sometimes ripped out in favor of large rectangular fields, laid out with little regard to slope. The result: increased erosion.

Even so, up to now, new technology has increased overall soil productivity more than erosion has reduced it. This will continue to be true at least for a time. Conservation tillage, limited tillage, reduced tillage and zero tillage are being developed and will reduce the threat to our productivity.

There are numerous statements that the discovery of new agricultural knowledge is lagging. This widely-held but erroneous view comes from measuring only the Federal agricultural research expenditures for the traditional agencies, which are the U.S. Department of Agriculture and the State Agricultural Experiment Stations.

While these agencies have experienced no real growth during the past 15 years, new agricultural research institutions have been increasing in number, in resources, and in the supplying of new knowledge. Among them are: the international research network, which produced the high-yielding varieties of wheat and rice; the private foundations, which developed our antibiotics; and the non-land-grant universities, which discovered DNA and gene-splicing.

Some people say we have pulled the available knowledge off the shelves and that it is already in use on most of the farms. But evidence to support this view is in doubt. In Iowa, yields of corn per acre continue to rise, both on average farms and on the better farms, and the margin of the better over the average continues at about 60 to 75 bushels—much as it has been in the past.

No Breakthroughs?

One often hears this said: "Unless there is a new breakthrough, we are in for tight supplies." One should ask: "Why think in terms of no breakthrough?" There have been intermittent breakthroughs ever since agricultural research began, a century ago. Why suppose they will end?

Working for breakthroughs is like drilling for oil. One never knows whether he is five feet from a million dollars or a million feet from five dollars. But it is unrealistic to predict all dry holes.

There likely will be new technology. Maybe gene-splicing. Maybe textured soy protein. Maybe nitrogen fixation for non-leguminous crops. Maybe salt-tolerant crops. Maybe wide crosses, like triticale. Maybe twinning of beef calves. Or improved photosynthesis. Or supplemental irrigation. Maybe computer-aided management. Or something that we cannot now imagine.

Allegations that efficiency gains in agriculture are tapering off cannot be supported by examining the record:

Annual average rates of changes in productivity in percent per year, U.S. agriculture, 1870-1979

1870-1900	+1.0
1900-1925	-0.2
1925-1950	+1.3
1950-1965	+2.2
1965-1979	+1.8

Anticipations of a leveling-off in productivity and efficiency are in considerable part the reflection of a mind-set oriented toward shortage.

Energy, Weather

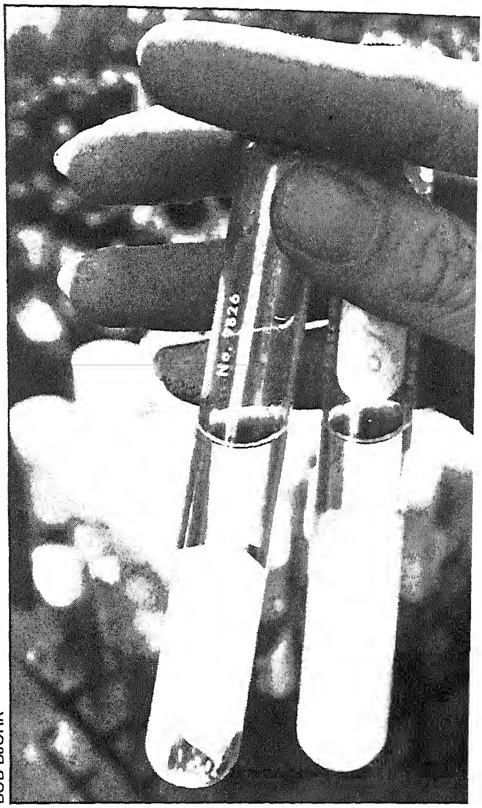
Will the tightening supply and high cost of energy seriously limit agricultural production in the years ahead? In certain areas and for particular crops this will be true. Fuel for lifting irrigation water from deep wells is an illustration. But for most farm products the average dollar spent for energy will return much more than a dollar's worth of production. This is true whether the dollar is spent for such varying forms of energy as fuel, fertilizer, or pesticides.

With a rising cost of energy there may be some cutback in use, at the margin. But as efficient energy users, farmers can afford to bid against their competition.

As for the weather, no one knows what it will be like in the years ahead. Long-range weather forecasting has not yet reached a state where it is useful. The best indication for the weather of the 1980's, both as to the average and the departure therefrom, is the weather of the previous several decades. Gloomy forecasts about the weather of the next decade tell us more about the forecaster's state of mind than about the weather.

On balance, it seems that after decades of decline, the trend in real prices of farm products is likely to stabilize or rise modestly during the years ahead. It will be good if this happens. By "real price" is meant the price corrected for inflation.

Rising real prices will result in the commitment of new resources to production and so an increased output.



BOB BJORK

There have been new breakthroughs in farming since agricultural research began. There is no reason to believe they won't continue.

They will ration out the supply among competitive users and we will have neither a chronic surplus nor a lingering shortage condition. We will have something like equilibrium, with years of heavier-than-usual supplies and other years of less-than-average stocks, depending on weather and markets.

Why the Scarcity Scare?

How explain the shift in public perception, which labeled the years from 1933 to 1973 a time of surplus and

which now considers the prospect to be that of scarcity?

For 40 years we held agricultural prices above market clearing levels. Fundamental economics tells us that if the price of a competitive product is held substantially and continually above where the market would have it, a surplus will result regardless of what the previous supply-demand situation may have been. The "surplus" of the 40 years from 1933 to 1973 reflected some share of this cause. Price policies in Western Europe as well as in the United States illustrate the principle.

Now that we are for the most part pricing our products competitively, the "surplus" has disappeared. We are generally in equilibrium. This should not surprise a good analyst. We are now essentially market-oriented. A fundamental rule of economics is that in a competitive industry, if the market is allowed to function, supply and demand will come into balance at something like full use of available resources.

For linear thinkers equipped with computers, two points make possible the location of a third. We have come from surplus to equilibrium and the projected next stage is scarcity. An econometric model which ignores the effect of price or which applies short-term price coefficients to long-term projections will inevitably predict disaster. It is like an automobile set in motion with the steering wheel locked in a fixed position.

The prognosis of disaster might turn out to be correct if in our concern about inflation we should endeavor to hold food prices below the competitive level. There are demonstrated methods of doing this: embargoes, price controls, and manipulation of supplies with price-depressing intent. All of these were used briefly, during the mid-Seventies.

Cheap Food Policy

In a country now 97 percent nonfarm and with widespread concern about high food prices, a cheap food policy might be attempted. The rationale for holding down food prices in such setting would be that "scarcity" provided a setting within which the food trade could "gouge" the helples consumer.

Fundamental economics tells us that if we hold the price of a competitive commodity substantially and continually below the market clearing level, a shortage will develop, whatever the previous supply-demand situation may have been. Egypt and Bangladesh, with their cheap food policies and their food shortages, illustrate this principle.

During the Great Depression, when prices were low, "surplus" was the accepted explanation. The surplus explanation took hold even though the production of crops and livestock during 1930-34, the five first and worst years of the Depression, was actually 2 percent *below* the production of the 5 preceding years, 1925-29. People know that, other things equal, a large supply means a low price. They saw the lov price and reasoned that the supply must be large; they didn't look at the actual volume of production.

With inflation and high prices for almost everything, people think supplies must be scarce. They know that, other things equal, a short sup

ly means a high price, and reason iat if prices are high there must be shortage. They do not look at the icts. Interestingly, while the "scarcity syndrome" was in gestation, durig the years 1978-80, total production of crops and livestock was 6 perent *above* that of the three preceding ears.

During the time when the percepion was that of low prices caused by urplus, we boosted the prices and reated a surplus; the assessment beame self-fulfilling. Those who had liagnosed the problem as surplus vere able to point to the accumulated government stocks as evidence that hey were correct.

The danger is that during a time of nflation the perception may be that of high prices caused by shortage; we may hold prices down and the assessment of shortage may become self-fulfilling. Those who said the problem was scarcity would be able to point to empty grocery shelves as vindication of their assessment.

The difficulty comes from trying to cure with commodity programs the inflation and recession that have their origin not with the commodities but with inept fiscal and monetary policies.

The food situation is complex. From the great array of facts and perceptions, a person with a particular mind-set can select out those pieces of evidence that confirm his predisposition. This he does subjectively, without intending to deceive himself or others. The mind-set is thus reinforced. A person with some other mind-set can look over the same array of fact and opinion and select out those items that support his presumptions.

In a particular setting one or the other of these perceptions can be picked up and mightily reinforced by the media. This explains, in part, the Surplus Scenario during the Depression and the Scarcity Syndrome during the Inflation.

Enough Food *IF*

"Enough food?" is the question asked in this chapter. The answer is, "There will be enough *IF*:

"*IF* we permit the market to give farmers the price incentives they need, and

"*IF* we avoid subsidizing the conversion of a substantial share of our high-value food into low-value non-food, and

"*IF* we make the needed investment to develop and distribute new agricultural knowledge, and

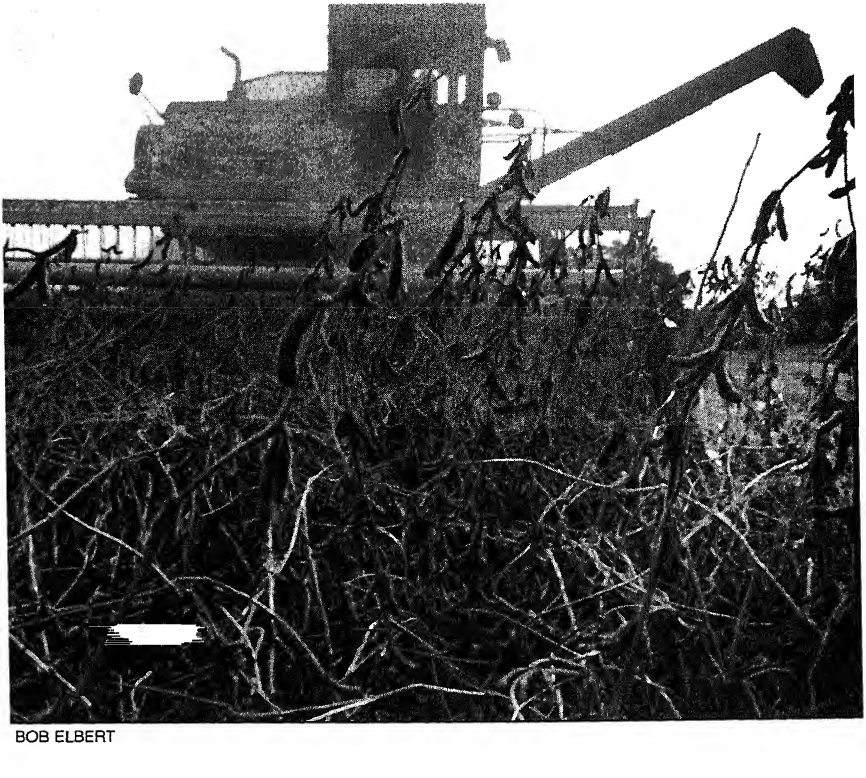
"*IF* we share with the developing nations the knowledge and experience we have gained during the past century, and

"*IF* the developing countries themselves work diligently on both sides of the food equation, improving their agriculture and reducing the rate of growth in their population numbers."

Enough Food? Yes, if we act wisely. If there is scarcity it will be because, with unwise policies, we have brought it upon ourselves.

It is a time for hope, which energizes, not for despair, which enervates. We are the first generation to possess the capability of banishing hunger. We will earn the thanks of future generations to the degree we perceive and act on this fact.

Don Paarlberg is Professor Emeritus, Purdue University, West Lafayette, Indiana.



BOB ELBERT

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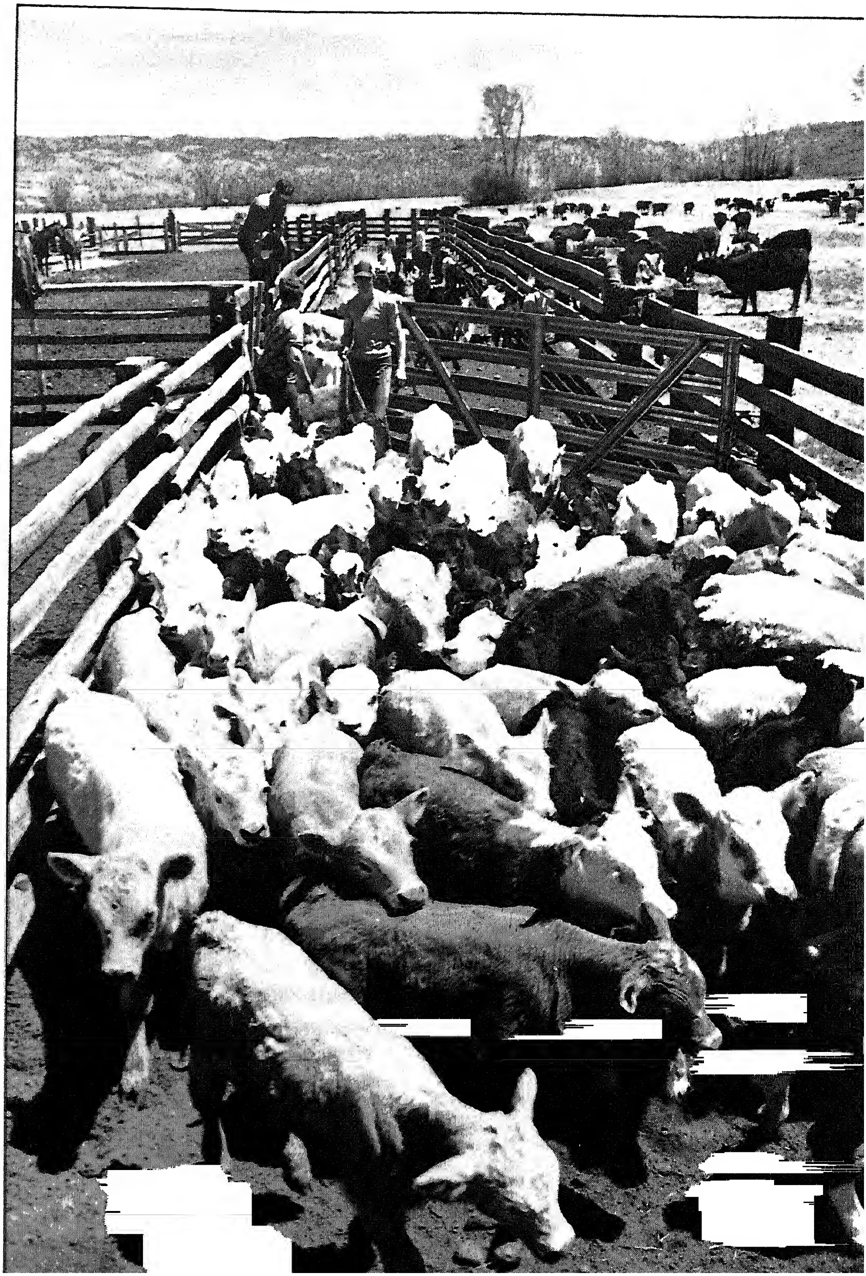

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